PIBS 1566

Industrial Waste Diversion Program

Final Reports #6

A DEMONSTRATION OF APPLYING ATS THERMAL SCREW PRESS TECHNOLOGY TO THE PROCESSING OF SEPARATED CONSTRUCTION AND OTHER WASTE MATERIALS

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INDUSTRIAL WASTE DIVERSION PROGRAM

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Report Prepared For:

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Report Prepared For:

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DISCLAIMER

This report is in partial fulfillment of conditions of a grant given to Spider-Maple Lift Limited by the Ministry of the Environment under the Industrial Waste Diversion Program. The report was prepared by D. Jones, A. Golan, and H.A. Bosschieter for Spider-Maple Lift Limited and documents results of work for which the Ministry of the Environment provided financial assistance.

The views and ideas expressed in this report are those of the authors and do not reflect necessarily the views and policies of the Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

SUMMARY

A demonstration was carried out by Spider Recycling, a waste haulage company, to determine how to sort, process and recycle or reuse waste disposed of by the company, using a new processing system based on ATS thermal screw press technology.

Selected loads of waste (totaling one thousand tonnes) from construction, sawmill, landscape and tire industries located around greater Toronto were delivered to a pilot separation and processing site and separated into piles of similar materials such as wood, drywall and tires. The separated piles were then drawn on as feedstock for processing through the ATS thermal screw press system. Usable forms of product and raw material were made by processing through this machine.

The applications demonstrated included turning wood waste into firelogs or wood fuel; yard waste into mulch; waste drywall into gypsum powder; tires into crumb rubber; asphalt shingles into a bitumix; and mixed garbage into densified logs or flakes. Wide ranges of throughput were found depending on the material processed, material size, density, moisture content and model of the ATS thermal screw press used.

This demonstration established that it is practical to separate selected wastes from industry and process these with the ATS thermal screw press into usable forms. It also became clear that this versatile machine could be the basis of an integrated recycling centre because of the flexibility in materials that can be processed. A system based on this technology needs an infrastructure of support equipment to aid in waste separation, breakdown, conveying, final processing and storage.

Indications are that the ATS system could profitably offer recycling and reuse solutions to separable waste where product markets were available and in some cases where the operation could collect the estimated $100 tonne tipping fees available in Southern Ontario.

The authors of this report encourage the construction and running of full scale integrated ATS plants in order to verify the feasibility of our trials.

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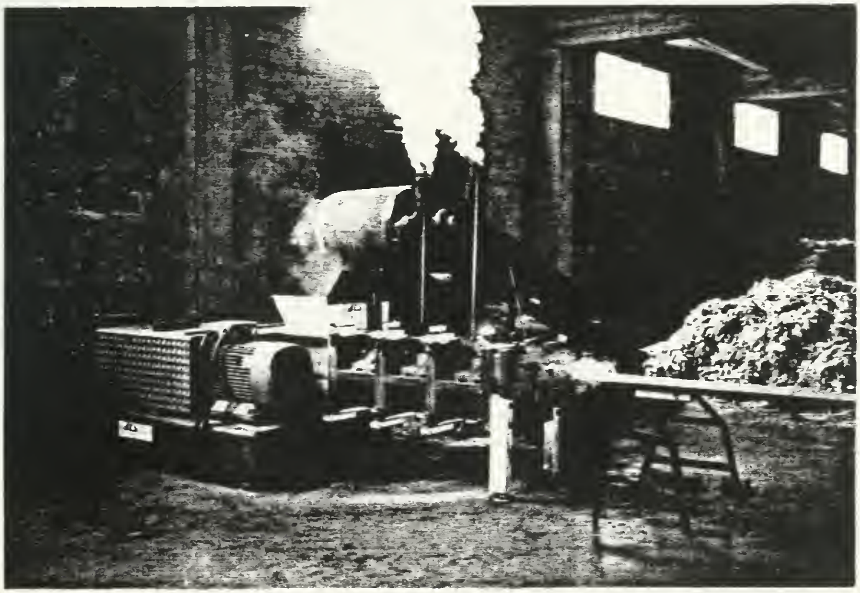


Photo 2. ATS - Thermal Screw Press Model T-4 extruding wood logs

1.0 INTRODUCTION

1.1 Background

Spider Recycling is a waste management business that primarily serviced industry through the haulage of waste (about 70,000 tonnes/year) to landfill sites from construction and commercial business in and around Toronto. Much of this waste appeared reusable if separated.

The company allocated funds several years ago, as the garbage crisis began to gain momentum, to investigate and develop a recycling system for processing waste picked up and landfilled by the company. Due to the major problem in recycling being the economics of carrying out such a process, the company looked at ways to develop value out of the potentially recyclable materials found in the waste hauled.

The Ministry of the Environment had brought out its 4 Rs program and because of Spider's experience it was granted cost-shared assistance of $134,615 to undergo this developmental project. This report summarizes the work carried out. As the cost of disposing of waste at the landfill increased during the period of this project, from $15 tonne to $100 per tonne, the concept of separating waste to recycle has tended to appear more economical.

There continues to be some urgency in finding and applying solutions as the greater Toronto area dump sites are expected to be full within a few years.

Spider targeted to use a Swiss machine called the ATS thermal screw press (photo 2) as it showed potential to achieve many recycling applications aimed at by Spider. Initially the machine was considered solely for producing densified woodlogs from waste wood but developmental work through research demonstrated many additional capabilities of this machine.

1.2 Purpose of Project

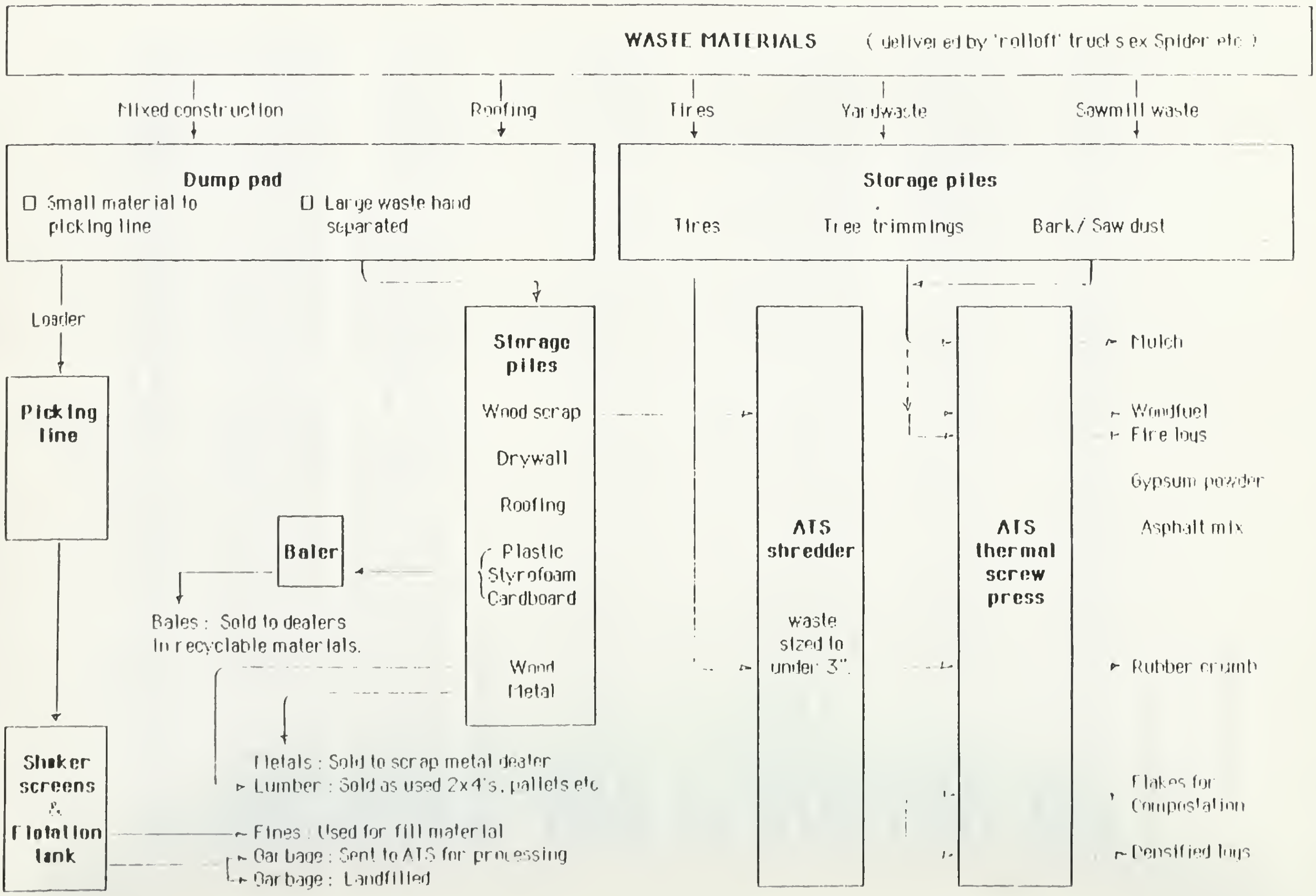
This demonstration was set to analyze the separation of waste hauled by the company, such as the construction waste (figure 1). After a separating process the specific waste components with the ATS thermal screw press changed them into new raw material forms or products thus demonstrating the potential uses for this technology.

The project set out to determine the percentage of waste that could be diverted through recycling and reuse under an organized approach utilizing ATS technology and thus relieve the pressure on landfills and the economic burden on Spider clients. This goal was not reached due to the recycling facility being burnt down during the project, but much necessary data was collected to indicate the concept feasibility.

The main consideration in directing the course of this project was that of profitability. The demonstration was evaluated for it's effect on revenue and adjustments to the original plans were made accordingly where cost made certain recycling activities uneconomic.

Figure 1

'Waste processing flow diagram'



1.3 Location of Processing

The demonstration was located at 477 Brimley Road, in Scarborough, Ontario. This site is referred to as "Brimley Recycling" (photo 1) and developed into a joint promotional facility for both Spider's research and demonstration for the MOE and the development facilities for Thermofriction Waste Recycling Inc. ("TWR") the marketing representatives for the ATS technology in North America. This location was chosen due to the staff and management available at the site and amenities that are beneficial to a recycling facility such as truck scales, central location, concrete crushing equipment, a large building, dumping yard and other backup services.

1.4 Demonstration Plan

The demonstration plan encompassed delivering waste collected from industrial waste generated by Spider Recycling "roll off" trucks, separating this material into components that could be recycled/reused in some form and processing them through ATS equipment. Initially source separation was considered as one alternative to collecting reyclables but reluctance of clients to participate in such a program led to the abandonment of this plan.

Instead, loads of waste were delivered to Brimley Recycling and separated on a dump pad (figure 2) and additionally separation through using other mechanical equipment such as a picking conveyor, floatation tank and shaker screen.

The separated material stored in piles (photo 8) then acted as the base material for the ATS demonstration work. The ATS-ATS was used as the central processing unit taking the selected separated materials and transforming these into new acceptable forms of products that would have value to society in some way.

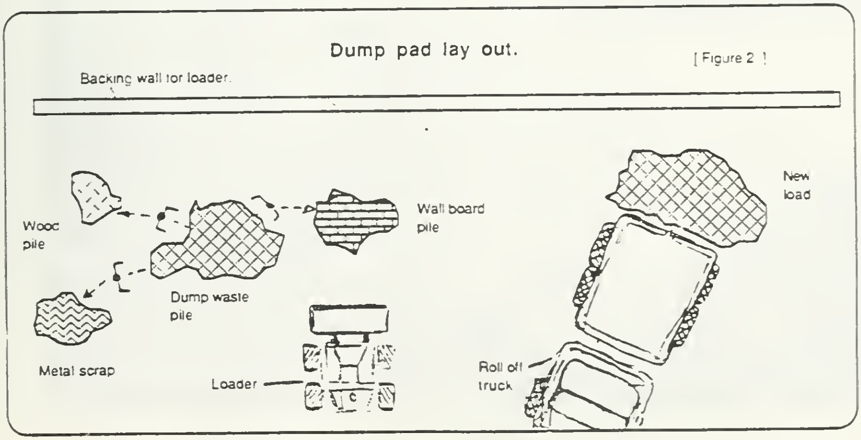


Photo 3. Portable ATS-Thermal Screw Press

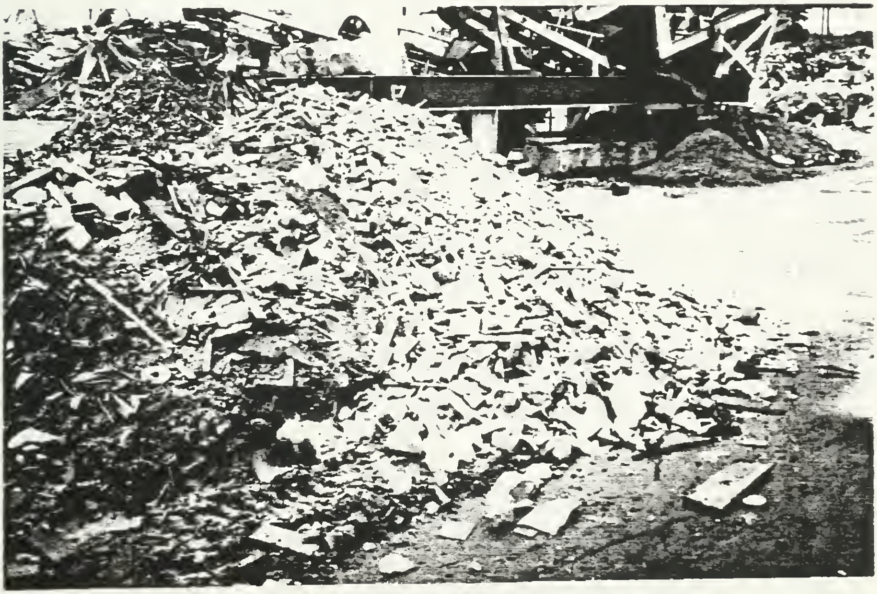


Photo 4. Waste ready to go over the Picking Line & the Shaker Screen

2.0 CONSTRUCTION WASTE SEPARATION

2.1 Introduction

The first consideration necessary to use the ATS technology in recycling was to separate waste into specific components, such as wood, drywall, asphalt roofing, etc., to ensure a uniform material for feeding the ATS-TSP machine. The separation of waste into component materials of similar nature is essential for reuse. This could be carried out in a variety of mechanized ways with modern technology but due to high equipment capital cost, economics limits the choices for most parties interested in recycling. In this research project the same restrictions applied.

2.2 Source Separation at Waste Generation Site.

Source separation is a desired first step to recycling of waste but this approach is heavily dependant on the support of the waste generator. Spider Recycling approached clients to work with using the source separation concept for the demonstration. They found a reluctance by the customers, at that time, to change their waste disposal pattern, that being disposal in a mixed state which is their most convenient and labour saving approach.

The source separating approach is preferable from a recycling business point of view as it can cut processing costs for the recycler. Source separating enables each recyclable component to be taken to its final destination on the first lift. In addition, the weight of an average mixed waste load coming from a construction site is only between 3 to 5 tonnes. Light loads on the truck mean a greater number of nuisance loads trucked through a city, thus adding to the cost of waste disposal.

Waste generator reaction to source separation: The high cost of union labour in conjunction with the amount of work required to separate the waste, presented too costly a proposition for most contractors to get enthusiastic about recycling. When this project was carried out the small financial incentives did not outweigh the separation costs, and did not interest the waste generator sufficiently for them to take on the added problems involved in setting up the program, covering lost time in carrying it out, and policing the procedure to ensure workers separate waste correctly. As the demonstration did not have a budget to pay waste generators to separate materials and clients did not want to carry the extra costs, the source separation plans were abandoned.

Incentives: It is believed by the company that source separation will eventually become of more interest to the waste generator in the future as the cost of disposal increases and recyclers develop greater value for the separated materials and can support financial incentives.

Incidental waste separation: In many cases industry shows an incidental form of waste separation through throwing out specific materials at set times. If the waste is concentrated with recyclable materials the recycler can take advantage of this knowledge to decrease the separation costs. For example in the construction business wood waste concentrates in a bin during framing work and drywall waste is present when the interior of a building is being constructed. When construction is finished cleanup time tends to produce very mixed waste.

Concentrated wastes: Many industries specialize and have large concentrations of specific materials in the waste stream. As an example, in the roofing business a replacement roof job generates a waste that is predominantly 95% roofing. As asphalt roofing can be recycled using ATS technology this waste was put in piles for processing by itself as small portions of contaminants proved not to be a major problem to the product.

Location problem: Contractors in the construction industry run into logistical problems in separating waste such as in the case of highrise buildings where waste is often disposed of down a common chute into the dumpster. All the waste from the building is mixed because of the chute and increasing the number of chutes to keep waste separate is cost prohibitive. Source separation becomes impractical in these situations and sorting at the recycling station is the only other solution. Lack of space on the job to store bins for recyclable waste is another problem in built up areas.

Comments: It was concluded that the choice of separating waste at a construction site or the recycling station, in the future, is going to be determined on a site by site basis. The decision will be purely economic until laws force change. When conditions reach the stage that recycling is welcomed, waste hauler/recyclers will need to develop a new skill for analyzing the anticipated waste from each client and establish a potential use, if any, and how it should be processed. With tipping fees, low, most waste will continue to be landfilled. With tipping fee's high the progressive waste hauler/recyclers will alter their methods of business with separation and reuse of the waste in mind.

2.3 Recycling Station Waste Separation.

There were several varieties of waste types trucked in for the research work. Construction waste primarily was targeted but as new experience developed with the ATS-TSP it was found necessary to draw on other waste sources and to integrate these when needed. The use of bark and or tree trimmings in making firelogs proved beneficial to improve results. After the success of the initial test work with the roofing materials separated from the construction waste, more roofing waste was brought in. The grinding of tires in the ATS-TSP again showed promise and Brimley Recycling conducted additional testing on their own that subsequently led to the tire plant now in operation at the site.

Over 90 percent of the separation experience developed from the mixed construction waste. The construction waste brought in to Brimley Recycling by Spider for the demonstration needed separation. It was predominately composed of wood, metal, drywall, cardboard and dirt. All other components were considered garbage. Putting these materials out into individual piles was carried out manually with the plan to progressively become more mechanized with experience and where it warranted in the future.

The four separating steps planned were (1) dump pad manual separation, (2) picking belt manual separation, (3) shaker mechanical separation to remove fine material and/or (4) floatation separation. The waste remaining after the processing was considered garbage for either landfilling or when practical to be processed through the ATS-TSP to densify or flake.

Separation procedure: Waste was trucked into the recycling yard by Spider roll-off trucks, and dumped on to a paved pad for manual separation. The loads were selected at the site of the generation source for a high concentration of targeted materials and minimal contamination, such as paint, mud and garbage. The workers picked the large pieces of waste material, such as wood, wall board, metal and cardboard into piles. Manual separation was assisted by a skid steer loader. The dump pad was backed by a concrete back wall to aid the loader in picking up separated materials or to remove garbage.

Dump pad separation: The construction waste dumped is easily accessed on an open pad. The labour team of three and one loader operator would immediately start picking from all sides of the pile. The skid steer loader operator opened the pile up as needed and removed large pieces. It was demonstrated sufficient weight and volume could be moved per hour by this method to cover costs, provided the operation is managed well. Approximately 50% of the volume of the waste was removed by this work. The remaining small material was moved by loader and taken for the next phase.

Separation must be carried out quickly and requires a team of pickers that can work together where each individual knows his task and is trained about the purpose, value, and final use of separated materials. The speed by which this procedure is managed and carried out is important to the economics of the facility.

Loader: The skid steer loader used to support pickers has a "quick unhook" detachable front-end system that allows the loader driver flexibility to change from a grapple bucket to forks or a dump bucket as required with the minimum of difficulty. Very large pieces such as spiked telephone poles were removed by the loader as waste. Cement slabs were taken by the loader to the rock crusher. The fines and garbage were bucket loaded for processing over a picking belt and shaker screen. The loader was constantly busy aiding pickers, moving separated material, spreading out the waste, and clearing up the pad for new waste loads.

Pickers: The pickers manually built small piles of selected materials from which the loader picked up, using a grapple or bucket, and transported these materials to the storage piles (photo 5) for the ATS machine or some other recycling end, such as with the baling of cardboard (photo 9) or sale of scrap metal. It was found best to clear away each load completely before allowing the next truck to dump. A clean pad is important to ensure the hand separated materials are not mixed with other waste. This factor makes it necessary to have a large dumping pad to handle several trucks and an efficient loader.

The pickers are the heart of the waste separation. Pickers must develop a skill for this job to ensure they separate in a profitable manner. Their ability to separate quickly is first of importance, as they must be able to move sufficient volume/weight per day to cover their direct cost and the stations overhead.

It is beneficial that pickers are sufficiently knowledgeable to be able to identify the value of materials to maximize the profitability of the separation (photo 6). The recognition of valuable metals, such as aluminum, copper, brass and steel as well as good lumber is a key

Photo 5. **Wood Waste Storage Pile**

Photo 6. **Surveyor Stakes formed from Waste Lumber**

to an economic operation. In addition an understanding of problem type wastes such as treated wood which must be removed from other wood products, is also part of the skill needed.

2.4 Picking Line/Shaker Separation

After the majority of the large waste is picked out on the pad, the remaining small-sized material was to be taken to a picking belt where items of value were removed by hand, or as in the case of ferrous metals, such as nails, with a magnetic cross belt. The remaining portion was planned to pass over a shaker screen to separate fine particles from the larger garbage. The fine fraction (photo 7) made a material suitable for fill and the garbage remained for diversion back to the landfill. A floatation tank was also constructed to allow flexibility in the sorting.

Unfortunately no data was gathered from operating this equipment together as a unit. The reason for this was a major fire which burnt to the ground the main building housing the majority of the processing equipment. The fire occurred just as the equipment construction was finished.

Weather: The dump pad separation was carried out in the open air in this demonstration. This has it's advantages when the weather is dry as workers prefer these conditions as noise and dust are less of a problem. The ability to separate undercover is necessary for any ongoing facility as workers cannot separate during bad weather and water generally adversely effects the recycling procedure and potential use of the waste. A facility that has both open and covered separation areas would be ideal. All waste must be separated on the day of delivery within the shift period of delivery, so that the pad continually is clear and waste cannot become wet.

Picking productivity: The productivity of the pickers on the dump pad was variable and reflected the quality of each individual. It was found that a team of three pickers per load of dumped waste worked well. The most successful separation approach was to allow the pickers to work on one pile at a time until all the major material items were removed. The skid steer would then pickup first the piles (photo 8) of wood, drywall, metal, etc., and transport these to a storage site. The remaining waste was then to be moved by the loader to a belt picking line. In most cases it was possible to remove over 50 percent of the volume in this first picking on the dump pad. As the picking line was not constructed during the early work, some of the waste was put over the shaker screen.

It was established that an experienced picking crew of three men and one loader operator, working for 8 hours per day, could separate 25 tonnes of delivered waste each shift on the dump pad. (Note: this does not include the separation of the waste which is moved by the loader to the picking line. This data was never collected.)

Comments: As the construction waste in this project was selectively chosen for a high percentage of large components and recyclable materials, it was assessed a manual approach to separation can be economic where a reasonable tipping fee can be collected to subsidize the separation.

Photo 7. Fine Material from the Shaker Screen

Photo 8. Construction Waste separated into Metal, Cardboard, Wood, Garbage & Fines

The management of the picking operation is critical to the economics of this type of business. The goal is to get a quick turnover of waste, and sufficient waste separated per person to ensure the procedure is paying. The trial work demonstrated that for manual picking viability it is necessary to either have a dedicated self motivated picking crew and/or a foreman full time on the job overseeing the picking crew.

2.5 Analysis of the Separated Construction Waste.

The construction waste delivered for the separation demonstration came primarily from housing or high rise construction projects. Over 1000 tonnes of waste was separated during the period of the demonstration. The trucks which were directed to the demonstration were not taken at random but selected for heavier loads. The loads were also chosen by the drivers for materials that were targeted by the project and in some cases for other recyclables, such as metal. The greater heavy loads were usually rock and concrete, which could be handled by an existing rock crusher which was located at the back of the site.

It became evident that separating up to three-quarters of the waste into recyclable/reusable materials was not difficult, due to the open nature of the construction waste picked up. The main components of the waste loads that came in were concrete, wood, wallboard, cardboard (photo 9), metal, fines and garbage. Out of this selection of components the following percentage by weight of some form of usable material were derived.

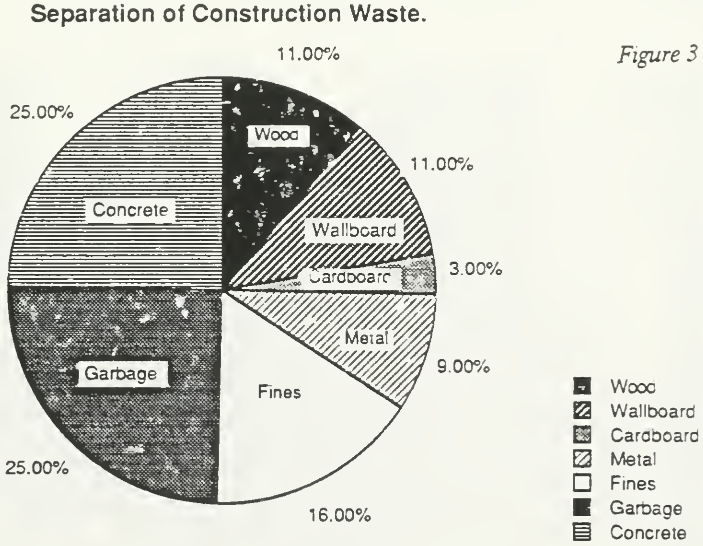


Figure 3

The diagram on the following page illustrates a calculation of the break down average of the construction waste as it was separated at Brimley Recycling. These figures were determined using only manual picking on the dump pad and the shaker screen.

RESULTS RECORDED FROM THE SEPARATION OF SELECTED LOADS OF CONSTRUCTION WASTE *Figure 4*

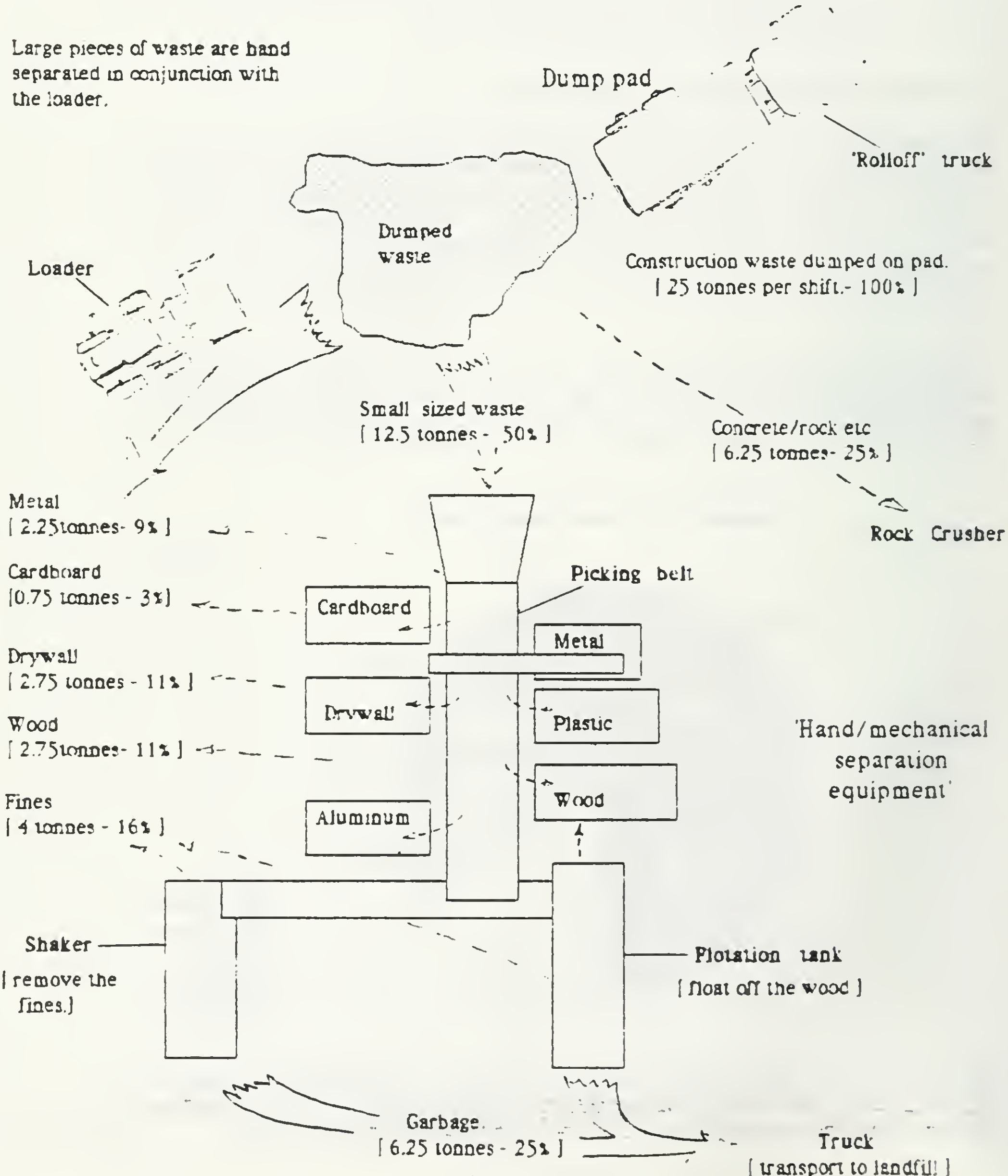

Large pieces of waste are hand separated in conjunction with the loader.
Dump pad
'Rolloff' truck
Dumped waste
Loader
Construction waste dumped on pad. [25 tonnes per shift.- 100%]
Small sized waste [12.5 tonnes - 50%]
Concrete/rock etc [6.25 tonnes- 25%]
Rock Crusher
Metal [2.25tonnes- 9%]
Cardboard [0.75 tonnes - 3%]
Drywall [2.75 tonnes - 11%]
Wood [2.75tonnes- 11%]
Fines [4 tonnes - 16%]
Picking belt
Cardboard
Metal
Drywall
Plastic
Wood
Aluminum
'Hand/mechanical separation equipment'
Shaker [remove the fines.]
Flotation tank [float off the wood]
Garbage. [6.25 tonnes - 25%]
Truck [transport to landfill]

Photo 9. **Baled Cardboard**

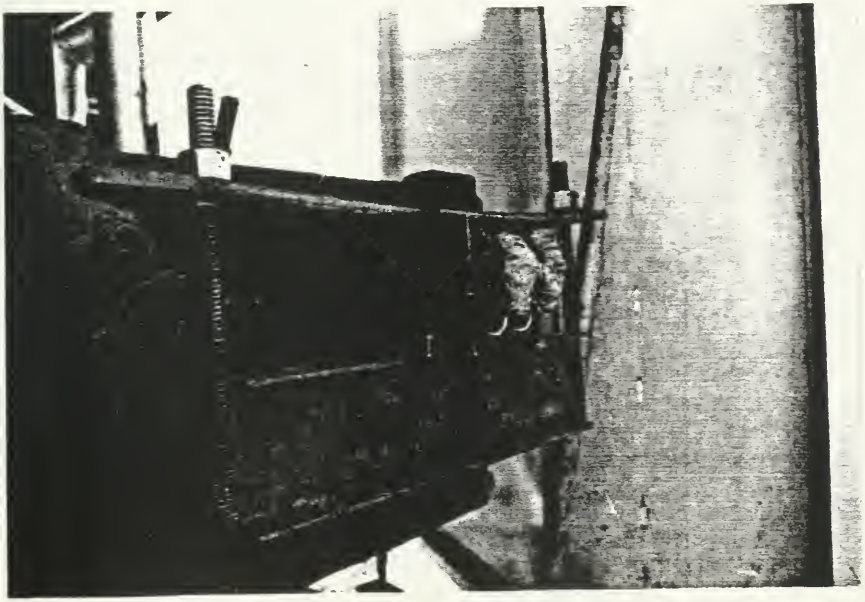


Photo 10. **Extrusion die**

Processed Material is densified through the back pressure created in the machine by the tension bar

3.0 DESCRIPTION OF THE ATS THERMAL SCREW PRESS

3.1 Background

Over a decade ago a Swiss Engineer started to develop a machine which would grind, compress and create an effect on organic materials and carry out this function in one step. The Aufbereitungs Technologie und Systeme (ATS) AG, company of Switzerland was founded to develop the patented concept and a number of prototype machines were built and improved on over the following years up to the current models of the ATS-TSP. Recently the ATS company was purchased by Canadian investors. A new marketing company, Thermofriction Waste Recycling ("TWR") has been established in Markham, Ontario, to manufacture components, assemble and market the ATS machines in North America.

The development of the ATS-TSP and related processing technology, has made it possible to utilize materials of biological or refuse base, with varying moisture contents, and in one step transform these raw materials into high energy fuel logs or mulch, create new formula animal feeds or extract increased levels of juices from plant cells. The flexible operating principle of the machine offers potentially a host of new applications.

In the past the ATS company focused development of the ATS-TSP for use in agricultural and forestry markets. Limited growth in these applications occurred due to the lower economic value of these uses, but there has been a recent change in marketing strategy by the new owners through the use of the ATS-TSP to process and recycle wastes.

The world wide solid waste crisis has provided many areas for potential development and application for ATS. Brimley Recyling Limited, TWR and its principals have on behalf of Spider-Maple Lift assisted with our research and developmental project and have provided information for this report on their testing and marketing programs.

3.2 Description of Machine

The ATS machine is a heavily built piece of processing machinery that fits into the dimensions five meters by two meters by fifteen meters and weighs between six to seven tonnes, depending on the model. This machine has twin.parallel extruding screws, which run the length of the machine, and pass through one to three processing chambers. These screws carry feedstock through a thermal friction processing technique created through the adjusting of friction plates that are located between the chambers.

The machine can be powered by electric or diesel motors and horsepower is transferred through a reduction gear box into two screw shafts. The screws turn together in opposite directions at 55 or 83 revolutions per minute. The final product released from the outlet comes in a compressed form. when adding the adjustable extrusion die (photo 10) which bolts to the end of the machine, or as flakes where no die is used.

3.3 Operating Principle

Function: The ATS-TSP is a machine which processes biomass and other waste materials in a completely new unique way, such that the feedstock is exposed to crushing, mixing, homogenizing, granulating, cell decomposition, compacting, heat generation, and moisture reduction, all in one processing step.

This function is carried out by two horizontal snail screws (photo 12) that run parallel down the length of the machine. These screws transport the feedstock or raw material feedstock from an intake hopper through several drying chambers and on out through a 100 mm outlet hole. These screws have variated interbound flights, that are different in each chamber.

Processing: During operation the ATS-TSP first disintegrates feedstock through the crushing action between the two parallel screws in the intake hopper turning against each other. The screws then pull the feedstock forward into drying chambers where further friction is created as feedstock is compressed against adjustable plates (photo 14) found dividing each chamber.

Heat is generated through friction caused by the forward pressure and turning action of the screws. Temperatures rise inside the machine causing the moisture removal and heating of the feedstock which results in melting with some materials such as asphalt and plastic.

Drying: Normal operating temperatures run between 105 and 125 degrees C. with moist biomass, as evaporating water controls the temperature. High temperatures cause the water in a feedstock to evaporate and these vapour vent through steam chimneys located at the top of each drying stage in the machine. Much higher temperatures can be reached with other processed materials where water is absent. As the raw material moves through the machine it is continually blended and dried, and progressively loses moisture as it moves from one chamber to the next.

Disintegration: The feedstock is exposed to high compression as it is forced against each friction plate. This in combination with the turning of the screws causes any biomass material structure to be broken down. The generation of steam inside the feedstock causes the cell walls of biomass material to rupture. This feature allows uniform product drying and homogenization as well as additional improvements to the nature of the new product formed, such as in the case of the increased digestibility of cellulose materials.

Densification: The densification of material with the ATS-TSP is achieved through adding a form giving die after the last drying chamber and creating back pressure on the screws. These pressures build up to 290 bar (4500 psi) during briquetting. Compressed products such as peat logs, wood briquettes, fertilizer sticks and plastic posts can be extruded and formed into various shapes based on die design. The machine will densify on a continuous basis and extrude product in most cases without the need of binders. The machine requires little adjustment when set for production, providing all related parameters remain relatively constant.

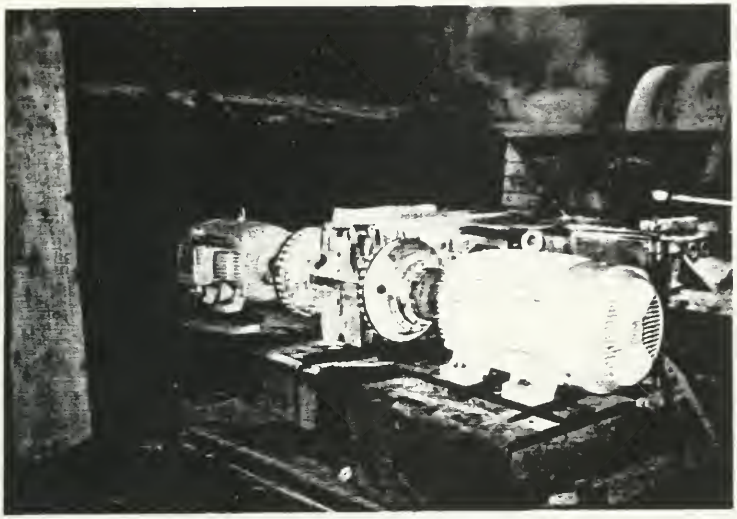


Photo 11. **Drive Mechanism**

Two 75 kw electric motors connect into an 18/1 reduction gear box using fluid couplings to maximize torque

Photo 12. **Internal Construction**

The machine is not complicated in design and parts can be easily removed for maintenance and repairs

3.4 Models

The ATS-TSP is available in several different model types. These are assembled to cater for varying requirements of feedstocks. The machine has one design size but components of each model differs to create the necessary function required by the material to be processed (see the model chart next page). The models of the ATS-TSP are generally differentiated by the number of chambers or friction surfaces, that make up the machine.

The four stage, three drying chamber model MG 2-300-4T, has been designed to create a high degree of friction and blending. This machine will cause significant moisture removal from a feedstock due to the four friction surfaces, and is capable of producing briquettes from materials with up to 50 percent moisture content (wet basis), providing the raw material will allow friction buildup.

Models with fewer drying heads are used for feedstocks with less heat generation/blending requirements. The MG 2-300-3T machines with three friction stages, are used for drying lower moisture content feedstocks (35 percent or less), such as is the case with most garbage. This model will uniformly disintegrate and dry garbage, or other feedstocks, making a flaked product or densified briquettes.

The MG 2-300-2T machines with two friction stations (one drying stage) is being used in the production of animal feed and offers higher production capacity for less moisture removal material. A special design MG 2-300-3T/E has been modified for liquid extraction from grass. This model will extract liquid from high moisture materials through pressure on the feedstock as it is disintegrated from one chamber to the next. This causes the juices to leave the plant material at an increased extraction rate over normal pressing methods. New model designs are being developed now with the addition of the new waste recycling applications. These machines may provide higher production rates.

The Spider demonstration was conducted with two ATS-TSPs. One is a specially built portable unit with an on board conveyor to feed the model 3T machine enclosed in a converted 7 meter shipping container (photo 3). A 270 hp Cat 6 cylinder turbo diesel engine powered the unit. The second machine was a model 4T powered with two 55 kw motors (110 kw) and a gear reduction to 55 rpm at the screws.

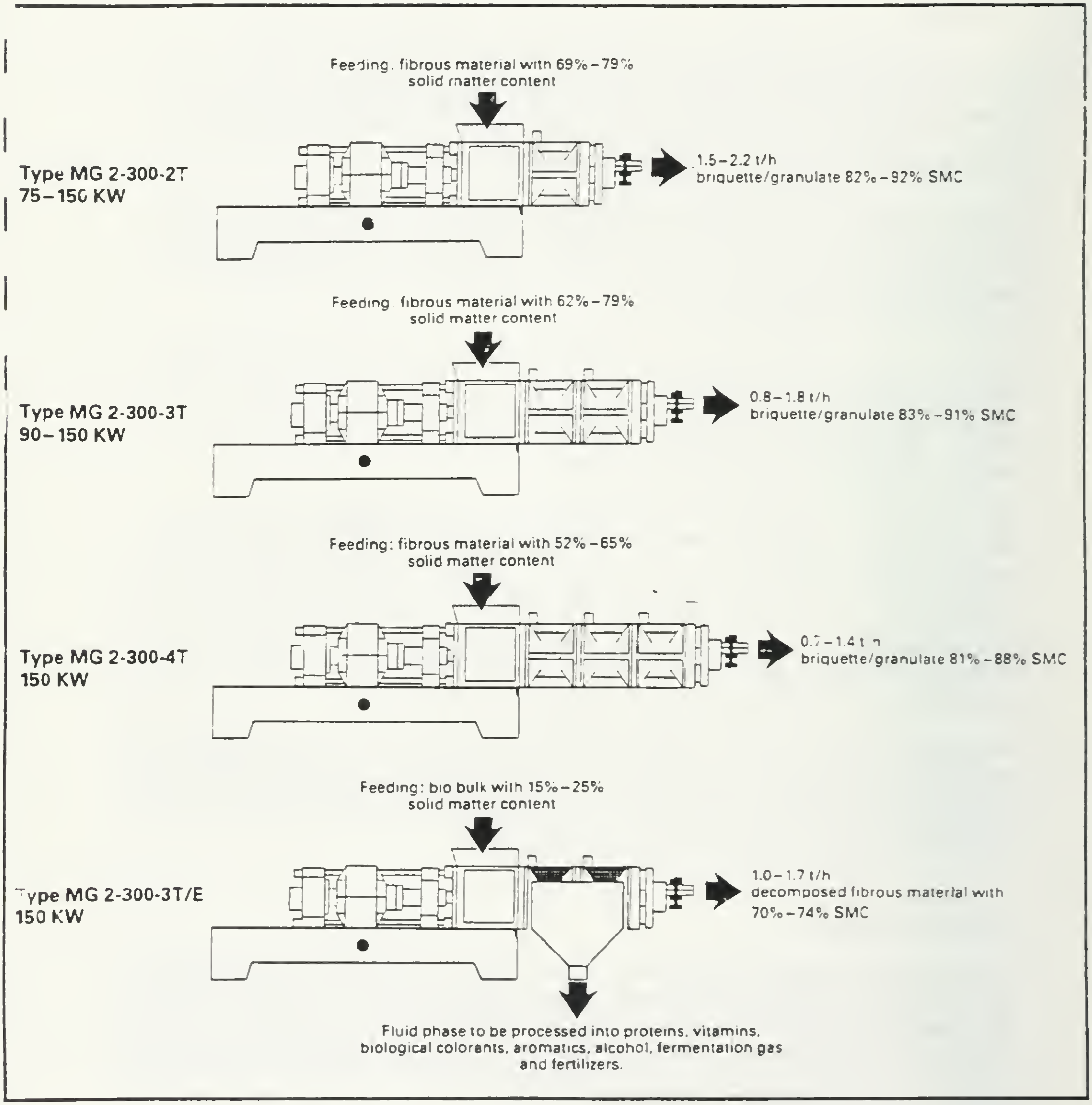
3.5 Production Rate

Production rate is influenced by a number of factors. such as energy input and rpm gearing, type of biomass material used, moisture content and final product form. For example in the manufacture of fuel briquettes. using press model MG-2-300-3T with two drying chambers and a 150 kw drive system (photo 11), the production rate can run from 0.5 to 1.5 tonnes per hour. Production increases as moisture decreases, partly due to less diversion of energy into friction which vaporizes the moisture.

Generally the production rate is going to be very specific to the material processed. Depending on the product size required throughput rates of over 3 tonnes per hour can be achieved in certain applications using the latest modifications and high density wastes. Several functions occur at the same time in the machine such as breakdown,

Model Chart

Figure 5


Feeding. fibrous material with 69%–79% solid matter content
Type MG 2-300-2T
75–150 KW
1.5–2.2 t/h
briquette/granulate 82%–92% SMC
Feeding. fibrous material with 62%–79% solid matter content
Type MG 2-300-3T
90–150 KW
0.8–1.8 t/h
briquette/granulate 83%–91% SMC
Feeding: fibrous material with 52%–65% solid matter content
Type MG 2-300-4T
150 KW
0.7–1.4 t/h
briquette/granulate 81%–88% SMC
Feeding: bio bulk with 15%–25% solid matter content
Type MG 2-300-3T/E
150 KW
1.0–1.7 t/h
decomposed fibrous material with 70%–74% SMC
Fluid phase to be processed into proteins, vitamins, biological colorants, aromatics, alcohol, fermentation gas and fertilizers.

homogenization, vaporization and compression and these are adjustable through control of the friction plates and extrusion die. The type of product desired is established by setting the machine after which a fixed production rate is determined. This will vary with every application.

Figure 6 and 7 which follow indicate recorded data for the three models mentioned in maximum and minimum situations processing biomass materials, showing the possible production rate spread. the graphs also indicate the effect of moisture on output. Production of briquettes and granulated material (mulch, flakes etc.) are illustrated separately as there is a significant difference in throughput.

In the Spider demonstration trials there were operational features that adversely affected high production results. The 4t machine which the early tests were carried out on was under powered with only 110 kw electric motors. Also this machine was geared down to 55 rpm which again limits the maximum output. As an example with this energy input only 250 kg/hour of fire logs was produced from sawmill residues of 45 percent moisture content.

Larger electric motors were installed later in the trials by TWR for their ongoing demonstration test work to bring the combined power up to 150 kw. It should not be a surprise that the power and production are so intertwined as the internal process is to crush feedstock and force friction to occur and heat to be generated. This need for increased energy also caused stress in other parts and components of the machines as the processing speeds were increased. Both electric and diesel machines decrease production where feed rates vary constantly. In addition variable properties of the feedstock, such as a 20 percent increase in moisture content also affects production.

TWR has initiated important changes to the power sources to make the machines more efficient and less costly to operate over the life of the ATS-TSP. These include the use of "Unity Plus" energy efficient motors that use about ten percent less electricity for the same power output. Greater power to run the machines and fluid couplings to increase the torque potential. When electricity demand is considered there is a startup and surge factor that must be allowed for in computing the sizing of the system and motors and in addition the gear box capacity must also be upgraded. It was not possible to get the higher production results in the early test work as these changes occurred later under TWR's development work on our behalf.

3.6 Production Characteristics in the Following Applications

Waste Disposal:

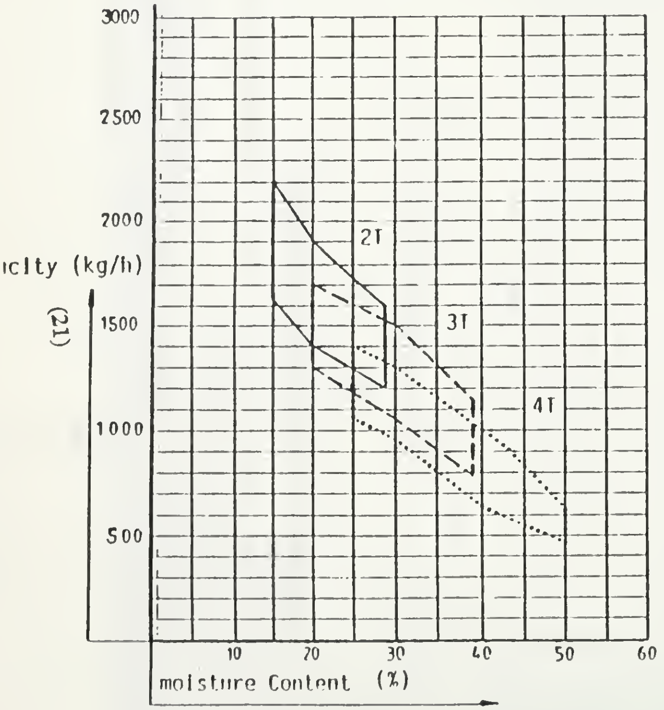
Feedstock....................greater than 60 % dry matter (40% moisture)
Driving power............150 kw
Vaporization power...-200 L water/hour(depending on the friction properties of feedstock)
Discharge output........max. 1200 kg/hour briquettes
max. 1500 kg/hour chips
max. 2000 kg/hour decomposed fibrous material
Screw speed ....81 rpm
Finished product.........max. 85% dry matter (15% moisture)

Production graph

Figure 6

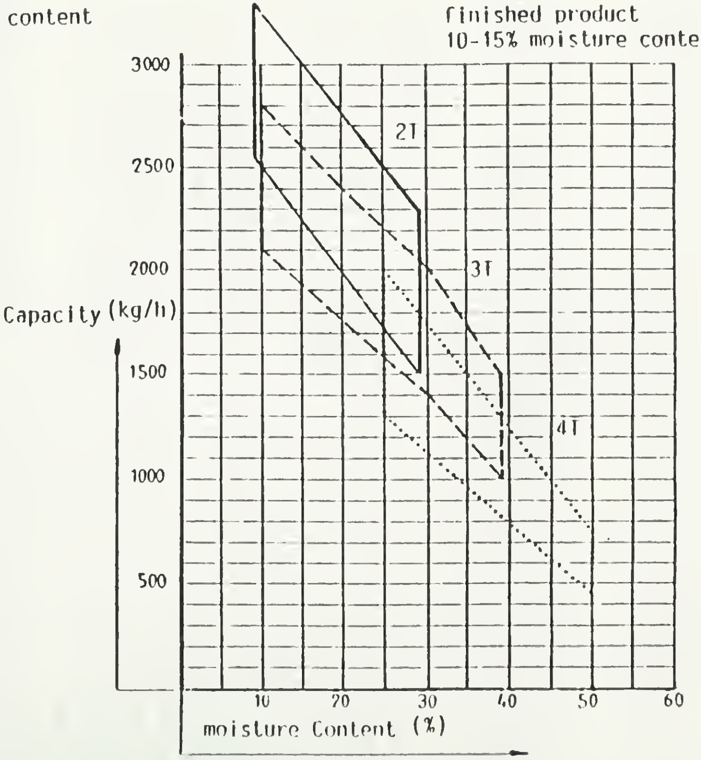
Briquetting :

Condition: driving power 150 kW
finished product 15-20% moisture content



Granulating :

Condition: driving power 180 kW
finished product
10-15% moisture content

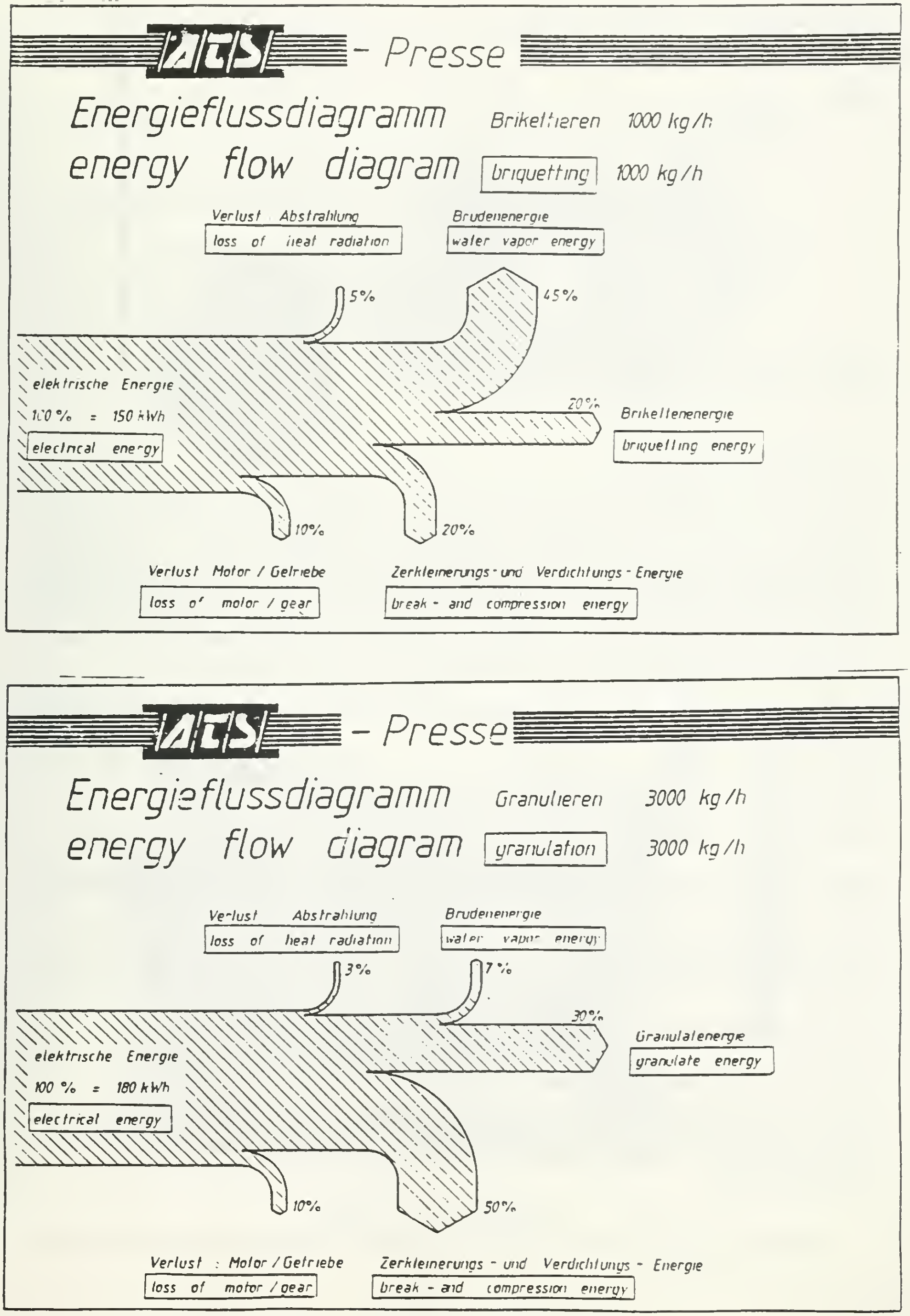


[This data is based on average measurements and experience with the ATS-TSP.
The results may vary, depending on the characteristics of the raw material, and
production rates should be confirmed through tests with the ATS-TSP.]

-------- 2-300/ 2T
- - - - - - 2-300/3T
.... 2-300/ 4T

Energy graph

Figure 7



Volume reduction.....refuse briquettes 5 to 10 time. depending on friction. Sewage sludge briquettes from screen belt press 2 to 5 times, decomposed fibrous material 2 times

Energy:	Feedstock	greater than 50% dry matter
	Driving power	150 kw
	Vaporization power	200 L water/hour (depending on the friction qualities of feedstock, e.g.. bark 150 L/hour)
	Discharge output	max 1000 kg./hour briquettes max 2000 kg./hour decomposed fibrous material
	Screw speed	81 rpm
	Finished product	max. 85% dry matter (15% moisture)
	Volume reduction	bark briquettes 3 to 6 times, coal briquettes 1.5 to 2 times

Note: The quality of the final product is further improved by the vaporization of 3 to 6 percent water during the cooling stage of the briquettes.

3.7 Maintenance Features

The ATS-TSP is essentially built with very robust components and designed for low maintenance. Built in features include no fast rotating components, no contacting parts in the processing areas of the machine and high abrasion resistance coatings. The machine also can be easily accessed for repair. An operator can now do resurface welding of the screws without necessarily removing them from the machine. The whole barrel assembly can be pulled apart in one piece or individual chambers can be worked on (photo 13). The screws pull off the shafts and are replaceable so that a second maintained set of screws can be changed on a machine within a shift and the operation can begin again quickly.

Generally the maintenance procedure is as follows (other specifics can be found in the operations manual):

- Daily: grease discharge bearings
- Weekly: Check transmission and thrust bearing oil level. Lube expansion bearing
- Each 700 operating hours: Check chambers and screws for erupted spots, and touch up with hard face welding rod when necessary (1/2 shift)
- Each 2000 operating hours: Turn star flight at the end of each screw to counter act wear or replace as conditions require (1 shift)
- Each six months: lube electric motor bearing
- Each 4000 operating hours: change transmission and bearing oil (1 shift)

(Maintenance is directly related to the feedstock processed and the setting on the machine. The more abrasive the material processed the more intensive the maintenance schedule will have to be.)

Photo 13. **Screw and Star Flight**

Screws are built with 2 parts./chamber. A front star flight takes 90% of the wear to reduce maintenance costs.

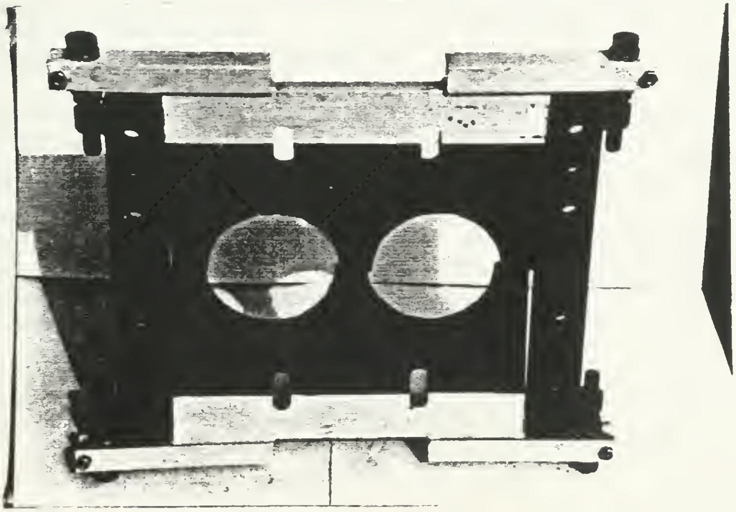


Photo 14. **Friction Plate**

This adjustable plate creates an opposing surface to the star screw. Here heat is generated through friction.

3.8 Plant Layout

What has become obvious is that the ATS-TSP must be used in a setting with other machines and conveyors It can do a lot but without the backup of the proper systems the unit can not reach it's full potential.

In each case there must be an area for accepting the material to be processed. If it is solid wastes then presorting, size reduction, metal separation and such must be undertaken before the material is conveyed to the ATS-TSP. This involves front end loaders, shredders and several conveyors. In some cases the solid waste will be too wet to process and a predrying system is required to warm up and preprocess the material for the ATS-TSP.

In the case of tires, they must be shredded to a manageable size that was preferred at less than 5 cm by 5 cm. Metal pieces such as rims and other tramp metal must be either manually separated or a magnetic metal removing system is required.

After the material exits the ATS-TSP conveyors are needed to take the production away to storage and also to recirculate any material that requires further processing. This recirculation is not uncommon when dealing with such a wide range of moisture contents, sizes and shapes of the various feedstock materials. Unfortunately these trials did not, for the most part of the operation have the required total system backup.

3.9 Early Applications

Spider brought these two ATS-TSP machines (first in Canada) over from Switzerland uncertain of their potential but hopeful that some applications could be reproduced or identified by this research project. Management initially thought the machine could process various sawmill wastes and agricultural residues to make biomass briquettes. In the wood area these densified products could be used for fuel. In the agricultural area they could be used for fuel but also in some cases as animal feed.

This aspect of a feed product derived from the processed materials lingers as each material is tested and product areas are defined. Feed can be for farm animals in the case of hay briquettes. It can be as feed for fish in the form of fish meal briquettes. It can even be in the form of feed using ground chicken feathers with the appropriate mixtures.

In Europe the main applications for ATS have been to utilize the sawmill residues. These are a major solid waste disposal problem around the world. The ATS-TSP can act to blend. dry and densify some of these wastes. This transforms them from often unburnable forms to a high energy fuel suitable for possible industrial or residential use.

4. WOOD APPLICATIONS TESTED

Wood has a variety of uses. Provided all the parameters such as quality, size type and cleanness are met it can be sold into a number of different markets. The key to succeed in these markets is to process the material so that the end product meets the consumer's specifications. The flexibility of the ATS-TSP has enabled the machine to be able to make various forms of product that can meet market specifications.

4.1 Wood Flaking

The ATS-TSP is capable of processing wood materials from many types of waste wood into a form, in bulk quantities, that is somewhat between wood shavings and a pulverized state (photo 15). These materials may then be used in a large variety of applications such as for:

Fuel - in bulk burners such as green houses
Mulch - in landscape or similar applications
Bedding - for horses, livestock or poultry
Compostation - blend with sewage sludge or other materials to be composted

4.2 Description of the Process and Plant for Construction Waste

Waste construction wood is generally completely dry and tests high in energy content (appendix 1) for wood but is usually very bulky and needs to be broken down. As the ATS-TSP operates best with a 10 cm. minus sized feedstock, all wood waste needed to be preprocessed through a shredder. ATS also make a low rpm shear shredder that is versatile and can break down a large variety of wastes including tires.

It was found that the typical equipment necessary for this type of plant consists of a shredder, magnetic heads, a two directional conveyor, screens, 2 ATS-TSP processing machines, 2 front-end loaders, storage bins, and electrical controls.

The waste wood material was brought to the tipping pad as in section 2.3. It was then sorted to remove any undesirable materials, such as bulky metallic objects, or other potential contaminants.

The waste wood such as broken pallets, construction and demolition materials to be processed must then be fed into the shredder to reduce the material to a size convenient for uniform feeding into the thermopresses. After the shredder a magnetic head was required to pull out the majority of metals. such as bolts, screws or heavy nails. The shredded material is then processed through the ATS-TSP which reduced the average size and moisture content of the construction wood waste. At the exit of the press another magnetic head will remove the remaining metals such as fine nails.

The wood product may now be stored in bulk containers ready for shipping or bagged to a desired size, all for preference of handling for shipping.

4.3 Flaked Wood Fuel Product

To get a good wood fuel for biomass burners it is important to understand both the handling systems installed to feed the fuel into the burner, and the type of burning method inside the furnace. With the biomass heating systems in Ontario the clients are looking for a uniformly sized fuel, low in moisture, preferably no inert material to create ash, and as high an energy value as possible.

Truckload samples of ATS wood fuel samples were sent (photo 16) to an interested greenhouse with wood burning capabilities. Wood particles of 2 cm minus were burned partially in suspension with most combustion on a fixed grate. It was found that the preliminary sample loads had too high a content of metal before the installation of the extra magnets. Metal such as nails, caused problems in the handling and feeding of the wood at the greenhouse as they plug up the grate area which affects both combustion and ash removal. Ash clean out problems occurred with the first sample burns when the metal and dirt was allowed into the furnace adding to the formation of clinkers. This led to the requirement of the second phase metal removing equipment at the Brimley Recycling site.

Construction wood meets the moisture content criteria as most material was under 15 percent. However it does contain small portions of dirt and metal. To produce the type of product desired it was found that the ATS with an open setting could make a fairly uniform 2.5 cm. material. There were no oversized pieces and a minimum of fines/dust generated, compared with product from high speed hammermills. The uniform product behaves better in storage and when conveyed, flowed evenly so that furnace feeding is constant to provide a predictable flow of energy. The type of crush breakdown of the wood by the ATS-TSP opens the pieces so that any metal such as nails are forced to separate from the wood and are easily removed magnetically. A shaker screen after the ATS in a production plant will additionally allow any dirt knocked free from the wood to be separated thus enabling the product to have as low an ash content as possible.

4.4 Flaked Wood Fuel Marketing

The commercial wood fuel markets have been adversely affected by the several year long doldrums of the crude oil markets and the easing of international tensions that could have interrupted supplies of fuel. The bulk fuel market also required more wood during the winter heating period.

Ontario Ministry of the Environment attitudes against using various solid fuels have also interrupted the development of potential wood fuel users and thus limited its short term market potential.

As biomass fuel is still a cheaper source of energy ($20 to $50 tonne) than fossil fuels, it will remain attractive to a consumer who already has an installed solid fuel system. The ATS wood fuel should be able to remain as first choice that a furnace owner would desire if it is priced competitively. The fact that the ATS method of breaking down the wood can help control many of the parameters, such as end ash content and higher energy content, are keys to success in marketing the fuel over competitor products.

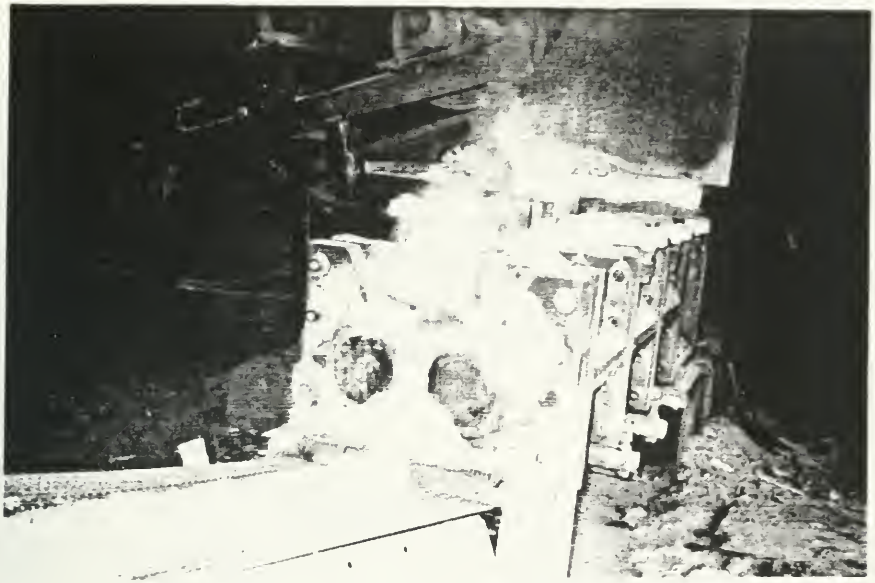


Photo 15. **ATS-Thermal Screw Press flaking Wood Wastes**

Photo 16. **Flaked Construction Wood Wastes being delivered for Fuel**

4.5 Animal Bedding Product

Animal bedding products need base materials that have high moisture absorption capabilities such as does cellulose. In addition biodegradable base materials are sought after to enable acceptable environmental qualities to be added to the features of the product. Again due to the uniformity of the ATS product this machine is now being investigated for use in this industry to make the base raw materials for "kitty litter". The fines produced can be used as a fuel or put through a granulator to form larger particles for use. Poultry also require a constant supply of bedding material that needs to have high absorbency qualities but little dust, features that the ATS product can meet.

It is hoped that these bulk products can be sold from a plant at $50 tonne or so wholesale. Other potential users may include larger livestock bedding.

4.6 Flaked Wood Economics

Production levels during the Spider testing were difficult to monitor. This was because of the variable sizes, moisture contents, types of mixtures of the biomass feedstock and the multitude of final products and size mixes. TWR was able from the tests to project on behalf of Spider various throughputs and how much the costs change as the eventual average hourly throughput is adjusted.

Test markets are available for the flaked wood product, made by the ATS machine, at a value of up to $50 per tonne. When the process is combined with a tipping fee of $65 per tonne a plant has a potential $115 tonne incoming revenue. Processing costs for the plant are calculated to total $54 tonne to take the separated wood down to the end product. An additional waste separation expense will need to be added where this applies, as in processing mixed construction waste. It appears if the products can be sold there is sufficient revenue in the following TWR profit analyses, prepared for Spider-Maplelift, to make such an operation profitable.

Table 1

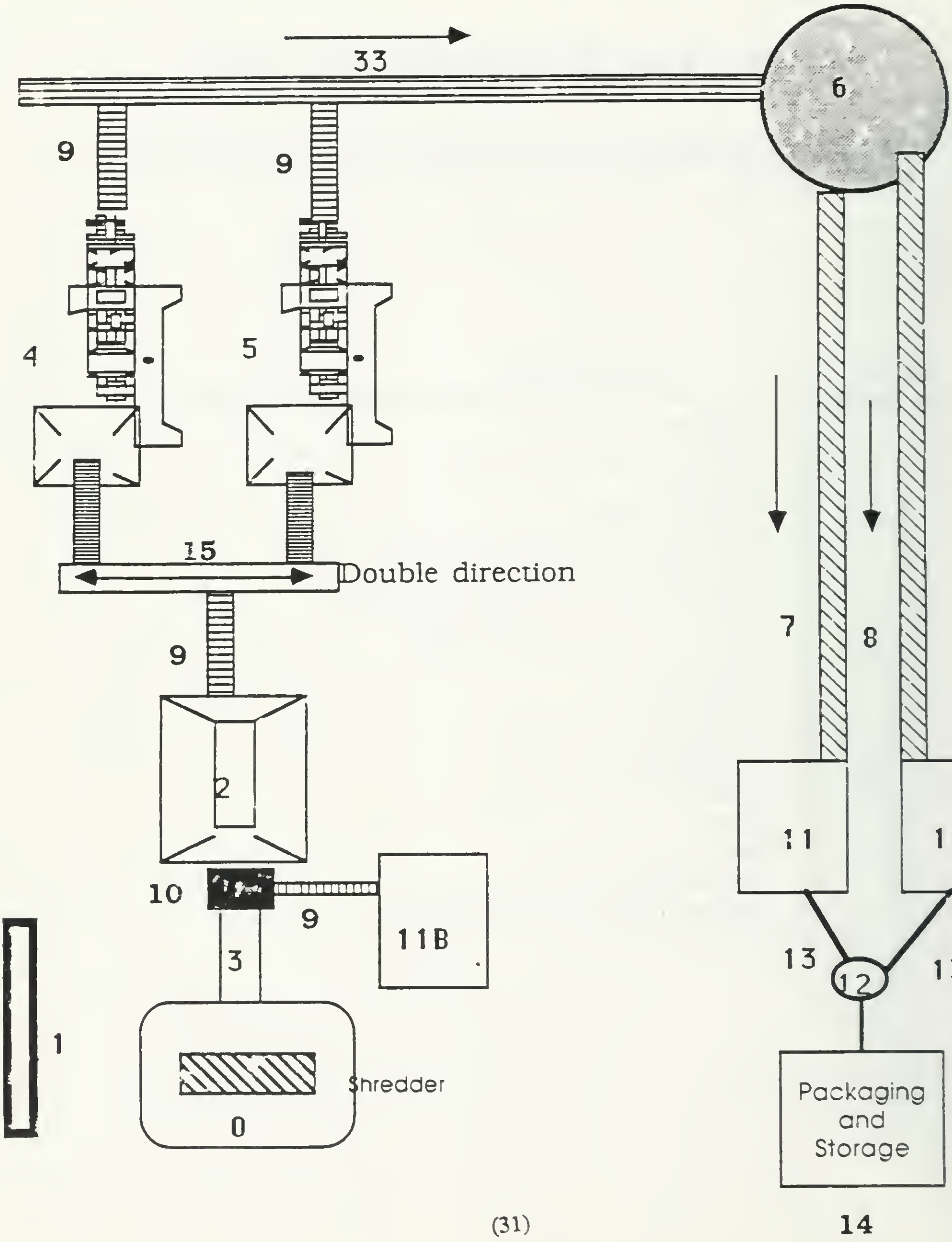
WOOD PROCESSING PLANT

GENERAL DESCRIPTION AND SPECIFICATIONS OF THE EQUIPMENT

CODE	DESCRIPTION
0	Shredder
1	Electric and command panel
2	Bin feeder.
3	Vibratory feeder
4	ATS 2-300-3T. 1x250 hp (unity plus)
5	ATS 2-300-3T. 1x250 hp (unity plus)
6	Circular vibrating screen- 60"ø (Kason)
7	Screw conveyor, 9"ø x 12' long
8	Screw conveyor, 12"ø x 15' long
9	Conveyor belt
10	Drum magnet
11	Storage bin product X
11A	Storage bin product Y
11B	Storage bin-steel
12	Blower
13	Plastic pipe - 6"ø
14	Bag packaging system
15	Two way direction conveyor belt1
33	Cooling/Drying belt

TWO THERMOPRESS LAYOUT FOR THE PROCESSING OF WOOD WASTE

Figure 8



WOOD PROCESSING PLANT - PROFIT ANALYSIS

Table 2

DATA

Number of ATS presses	2
Number of shifts	2
Operating hours per year	4,000
Throughput - Tons/hour/press	3
Production - Tons per year	24,000
Number of Workers per shift	3
Manager (1 shift only)	1
Labor cost per hour	$15
Power Consumption KW / hour	600
Charge per KW hour	$0.04
Tipping fee per ton	$65
Selling Price per ton (average)	$50
Amortization period - yrs	4
Cost of Funds	14.25%
Maintenance including presses	6%
Insurance	2%
Royalties on revenue	10%

INVESTOR'S 1st YEAR RETURN

Annual Profit	$1,455,049
Amortization and interest	$482,951
Total	$1,938,000

% Return on Investment 138%

INVESTMENT	Cash		Lease
Front End Loader			$30,000
Installation	$150,000		
Front Conveyor			$5,000
Bi-directional Conveyer			$10,000
Shredder			$150,000
Magnetic head			$15,000
Storage bins and screens			$100,000
ATS-TSP presses			$800,000
Miscellaneous & Startup	$100,000		$40,000
SUB TOTALS	$250,000		$1,150,000
TOTAL			$1,400,000

PROFIT ANALYSIS	per annum		per ton	
Costs				% of cost
Amortization and cost of funds	$482,951		$20	37%
Overhead	$120,000		$5	9%
Lease of Land and Building	$30,000		$1	2%
Maintenance	$84,000		$4	6%
Insurance	$28,000		$1	2%
Total Fixed Costs	$744,951		$31	57%
Power	$96,000		$4	7%
Labor	$180,000		$8	14%
Fuel	$8,000		$0	1%
Royalties	$276,000		$12	21%
Total Variable Costs	$560,000		$23	43%
Total Costs	$1,304,951		$54	100%
Income				% of income
Tipping fee income	$1,560,000		$65	57%
Income from sales	$1,200,000		$50	43%
Total Income	$2,760,000		$115	100%
Annual Profit	$1,455,049		$61	

WOOD PLANT OPERATION - SENSITIVITY ANALYSIS

Table 3

OPERATING HOURS VS PRODUCTION AND RETURN

Operating Hours	Production tons/yr	Return $
2,000	12,000	$838,000
2,500	15,000	$1,113,000
3,000	18,000	$1,388,000
3,500	21,000	$1,663,000
» 4,000	24,000	$1,938,000
4,500	27,000	$2,213,000
5,000	30,000	$2,488,000
5,500	33,000	$2,763,000
6,000	36,000	$3,038,000

NOTES:

1. Sensitivity analysis shows how the investor's total return varies with different operating points.
2. "»" indicates the planned operating point.
3. These tables are plotted on the following pages.

THROUGHPUT VS PRODUCTION AND RETURN

Throughput tons/hr/press	Production tons/yr	Return $
1.0	8,000	$287,333
1.5	12,000	$700,000
2.0	16,000	$1,112,667
2.5	20,000	$1,525,333
» 3.0	24,000	$1,938,000
3.5	28,000	$2,350,667
4.0	32,000	$2,763,333
4.5	36,000	$3,176,000
5.0	40,000	$3,588,667

INVESTMENT VS RETURN

Investment $	Return $
$800,000	$1,986,000
$1,000,000	$1,970,000
$1,200,000	$1,954,000
» $1,400,000	$1,938,000
$1,600,000	$1,922,000
$1,800,000	$1,906,000
$2,000,000	$1,890,000
$2,200,000	$1,874,000
$2,400,000	$1,858,000

TIPPING FEE VS RETURN

Tipping Fee $/ton	Return $
$25	$1,074,000
$35	$1,290,000
$45	$1,506,000
$55	$1,722,000
» $65	$1,938,000
$75	$2,154,000
$85	$2,370,000
$95	$2,586,000
$105	$2,802,000
$115	$3,018,000

AVERAGE SELLING PRICE VS RETURN

Selling Price $/ton	Return $
$30	$1,506,000
$40	$1,722,000
» $50	$1,938,000
$60	$2,154,000
$70	$2,370,000
$80	$2,586,000
$90	$2,802,000
$100	$3,018,000
$110	$3,234,000
$120	$3,450,000

5 SAWMILL RESIDUES

As pointed out wood processing has been the most widely used application for the ATS-TSP in Europe. It was with great hopes that the unit was to be demonstrated by Spider in Canada on a range of materials. It was decided to assist in the learning curve for operating the ATS-TSP that various conventional wood wastes would be processed.

Sawmill residues were acquired from various operators. These were mainly segregated batches of bark or sawdust from processed mixed softwood trees. The moisture contents varied on different batches from 30 to 50 percent. These materials were used as blending materials to combine with construction wood. The adding of these wastes was part of the development work of these trials.

5.1 Fire Logs Introduction

A key to marketing the wood waste is to process the material into a form that fits a market demand. Densified wood in the form of fire logs does this as firewood is becoming harder to come by and more expensive in big cities throughout Canada. Densified wood waste within cities to supply a local market is a concept to be encouraged, as it offers a use for the wood waste, reduces transport traffic and potentially helps saves trees.

5.2 ATS-TSP Processing

The sawdust and bark can be processed but the larger wood slabs need first to be shredded before processing in the ATS machine. The most flexible sizing system available to complement the ATS-TSP is a low rpm shear shredder. This machine can often tolerate a wide variety of materials from waste wood to steel belted tires.

Machine Operation: The ATS-TSP will take the product conveyed from the shredder and draw in the wood feedstock, grind it up causing decomposition of the cell structure of the wood. The friction heat generated in the machine vaporizes moisture in the wood. The hot disintegrated wood fibers become easier to bind together as the moisture levels drop below 15 percent and the lignins/resins become hot enough to hold the homogenized materials together. This all happens under high pressure due to the back pressure caused by the "die" tension device at the outlet of the machine.

Log Extrusion: Making logs with the ATS-TSP is a relatively simple process, providing all the parameters are constant, as the machine grinds up the wood in the machine heating as it travels through and driving off the moisture. The wood extrudes out of the machine at over 100 degrees C. The hot product is firm but can be broken easily by a compression cutter wheel (photo 17) into appropriate lengths. The hot logs continue to lose moisture in the form of steam as they sit on the pallets and they gradually go hard as they cool to ambient temperatures.

Photo 17. **Biomass Firelogs being extruded and cut into stove lengths**

Photo 18. **Storage of Palleted Firelogs waiting for delivery to Test Markets**

Storage: The logs can be hand removed from the extrusion rail and stacked on to pallets. A standard pallet (100 cm by 120 cm) holds 600 logs and weighs 1100 kg. After the logs have cooled the pallets can be stacked two high to save on storage space (photo 18).

Waste blending tests: To make firelogs from mixed waste materials requires a degree of skill on the part of the operator as certain materials make better logs than others. Many small tests were carried out to establish a profitable way to make logs from waste by avoiding the need to predry a feedstock. It was established very dry white woods such as waste construction wood do not make every good feedstock for logs alone due to the age and dryness of the wood. However by blending other wastes such as bark or other green wood material it was possible to make logs bind. To make the machine operate at reasonable production rate it is important to keep the average moisture content of the feedstock at about 25 percent.

As moisture content is often a variable feature of wood waste, to find the moisture content of wood waste around 25 percent is not common. Tests demonstrated that this problem could be overcome with the ATS-TSP through blending higher moisture waste with lower moisture material, as opposed to having to dry the wet feedstock first. For this reason a fire log operation would be able to access various waste sources, store these and blend as needed based on moisture analyses and type of material. As an example a facility might draw in waste from city tree trimming operations, bark from local sawmills, blended with construction wood wastes as source material to make the logs. The logs made from these blends do not make store package quality logs but are fine as a wood energy source for the domestic wood stove market.

Comments: The throughput of the ATS-TSP varied depending on the moisture content as well as the size and condition of the feedstock. Initially tests were conducted during 1988 on a 4T model with the 110 kw drive system. It was found that this combination could process only about 500 kg/hour. This relatively low production rate occurred with this low kw machine due to energy being forced to divert into additional functions while operating. The higher the moisture content of the waste the more energy that has to go into creating friction to drive off the water. If the wood waste that is fed into the machine is large the pieces require energy to break down and this again decreases the speed the product leaves the machine.

5.3 Comparison between ATS Firelogs and Firewood

The densified logs made with the ATS-TSP are natural in composition in that there are no additives, burn easily, uniform in size, require less storage space due to the densification, give greater heat value for the size and are dry. These logs also burn cleaner due to the fact that they usually burn at a higher temperature based on the use of clean materials. These qualities can help make the ATS-TSP technology one good solution to transform wood waste into products of value.

The comparison of densified logs with firewood by heat value has to be very general as firewood varies considerably based on the type of wood, growth conditions and degree of seasoning. Likewise the feedstocks for the ATS-TSP vary but the extruded logs are relatively consistent as to a high density (about 1 they don't float in water) which is twice as dense and energy packed compared to softwood fire wood. Furthermore the briquettes are many times more energy concentrated on a bulk density basis compared with the preprocessed construction wood waste or yard waste feedstock.

5.4 Storage

Logs made from waste wood materials were placed on pallets of 600 logs unpackaged, or packaged in 60 plastic bags of ten logs. It was found that logs could be made with up to 18 percent moisture content, but these logs did fall apart easily where exposed to wetting on the surface of the log. This could happen when rained on in open storage. A final moisture content of 10 percent is targeted for a good log. The lower the moisture content of the log the better the storage ability but compressed logs as a rule should be in dry storage.

5.5 Wood Log Marketing

It was found that there would be little difficulty to market the logs as the public readily accepted the product. Samples of these logs were given out for test marketing and all users responded positively to this product as a heat source. Use of the logs in the open fireplace did not give the same aesthetic feeling people are used to from firewood. The ease of use in startup was attractive enough for some clients to purchase the logs as dry fuel to prestart a fire. Cost was found to be a major determining factor in whether people would use this product. With a high enough up front tipping fee it should be possible to produce logs with this machine at a cost below that of firewood.

Logs made with some waste materials, particularly certain green woods, did not smell particularly like wood although they burned well and would be fine in air tight wood stoves. The form of the product offers benefits to the consumer of no wood splitting, less storage space required as the product has twice the energy in the same space as firewood would take up.

It was found that the storage of the firelogs was required if year round production was undertaken. This allows for enough supply to satisfy the peak firelog demand of the fall and winter months. It can be seen from the following analyses provided to Spider-Maple Lift by TWR that the machine needs to work year round to make the operation economic. However the storage of logs can also be a great expense to an operation in a city.

PROFIT ANALYSIS

Table 4

11-Jan-90		HEARST PROJECT	
	PER HOUR/TO	PER YEAF	
DATA			
ATS units	1		
Hours per year		4000	
Tons	1.2	4800	
Workers per shift	2		
Working hours		8000	
Labor cost	$20	$80,000	
Power KW	300	1200000	
Cost per KW	0.04	$48,000	
Depreciation on capital		5	
Calculated interest rate	On investment	13%	
Calculated insurance	On investment	2%	
Calculated maintenance	On investment	4%	
Moisture factor	1.2		
Cost of raw materials	$5 per ton	$28,800	
Price per ton of logs	$200		
Royalties per ton		$20	
Packaging materials		$20	
INVESTMENT			
Front Conveyor		$5,000	
Magnetic head		$10,000	
ATS Thermopress		$400,000	
Conveyor		$5,000	
Packaging machine		$40,000	
Miscelleneous		$15,000	
TOTAL		$475,000	
FIXED COSTS			Per ton
Capital return		$135,049	$28
Maintenance		$19,000	$4
Insurance		$9,500	$2
Overhead	10%	$32,000	$7
TOTAL FIXED COSTS		$195,549	$41
OPERATING COSTS			
Power		$48,000	$10
Labor		$80,000	$17
Royalties		$96,000	$20
Packaging materials		$96,000	$20
TOTAL OPERATING COST		$320,000	$67
TOTAL COST		$515,549	$107
Sales of firelogs			
TOTAL INCOME		$960,000	$200
PROFIT		$444,451	$93

6 YARD WASTES

Any material made of brush, leaves and other forms of biomass, can be transformed into a uniform type of mulch by the ATS-TSP. The waste must be shredded to a less than 10 cm size to allow even feeding.

6.1 Processing Details

The machine grinds the yard waste, mixing it, and heating the material to 120 degree C. thus taking the water content over the boiling mark. Water content inside the cells of plant materials also boils thus rupturing the cell walls and exposing the contents for biodegradation. It was found in Europe that processing material through the ATS-TSP would take several weeks off the compostation process time.

Demonstration Work: Spider work was mainly based on tree trimming waste available to the company. This material is basically 7 - 10 cm chipped green wood waste (photo 19). It was conveyed directly into the 4T machine (110 kw). The ATS-TSP grinds the wood waste material so that relatively long fibers are made from the wet wood. The machine removes 10 to 20 percent moisture content at the same time. The ATS-TSP Model 4T machine produced 5 cubic meters of this mulch per hour. Mulches had a retail value of $15 per cubic meter. This would give a potential value of $80 per tonne of tree trimmings processed if sold in the landscape garden industry.

6.2 Mulch Product

The product formed from the processing of green wood wastes is a long fibered mulch material that is well suited for garden applications.

Mulch production is much like the flaked wood and can be composed of many biomass materials. It was found in the trials that the ATS-TSP was very good at breaking down, and mixing or homogenizing biomass. This is important as mulches often have combinations of materials in specific proportions for different applications. The ability to explode the cells of the biomass also helps in the weakening and breaking down of the mulch material for its eventual integration into the soil.

Yard wastes were also very usefully processed into long fibered mulch pieces and the ATS-TSP blended the various branch, leaf and grass materials. In season these are very available and many municipalities are interested in composting or otherwise diverting this material away from landfill. Large quantities of food wastes are also available for composting and blending with the other biomass materials.

Photo 19. Shredded Yard Waste from Tree Trimming Operations

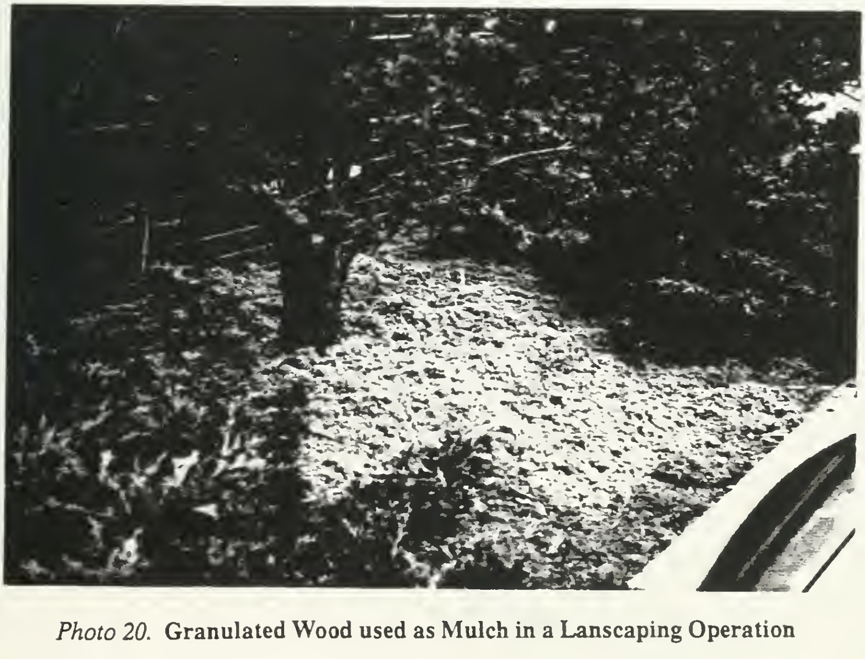


Photo 20. Granulated Wood used as Mulch in a Lanscaping Operation

[illegible]

[illegible]

6.3 Mulch Markets

Markets for fibrous kind of mulch (photo 20) include material for landscaping, parks, plantations and gardening. Spider made use of some of the mulch at their premises for landscaping and made other material available for testing and utilization. The benefit to these long fibered mulches formed is that it holds together on the surface of the soil and resists blowing when used as a landscape gardening material. The mulch inhibits the growth of weeds and helps retain moisture. The product is of course naturally organic when coming from yard wastes, and will integrate within the soil to increase the humus content. Being green, the yard wastes will break down slowly and consume nitrogen in the process, so it was found best as a surface-applied mulch put down shortly after the processing through the machine.

Soil mixtures are also a market by the addition of other available products such as peat, manures and farm residues.

6.4 Compostation Product

To compost materials numerous activities occur at once. If uniformity of size can be achieved in the material to be decomposed consistent decomposition rate and uniform end product can be made. In the case of compostation of sewage sludge it is state of the art to blend wood chips with the sludge for aeration and bulking purposes. Uniformly sized wood chips break down at the same decomposing rate thus avoiding the problem of some chips breaking down faster then others, making it difficult to get an even decomposition throughout the compost pile.

The ATS has a much greater benefit for the composter as processing of the total compost mix through the ATS-TSP has been demonstrated in Europe to decrease the time to aerobically decompose biomass. This is partly attributed to the biomass cells being exploded by the vaporising moisture found in each cell.

6.5 Mulch Economics

The cost of processing wastes into mulch using the latest ATS-TSP have been calculated by TWR on behalf of Spider-Maple Lift as follows. The total processing costs are estimated at $29.87 per tonne when processing 32,400 tonnes per year. This would enable an operation to run profitably giving the product away for free.

Table 5

INVESTMENT			
Front end loader	$40,000		
Front Conveyor	$5,000		
Magnetic head	$20,000		
Conveyor	$5,000		
Front forklift	$40,000		
2 ATS Thermopresses	$800,000		
TOTAL	$910,000		
DATA		PER YEAR	
Number of presses	2		
Operating hours per year		4,500	
Capacity per machine	3 ton per hour		
Number of Workers	2 per shift		
Number of shifts	2		
Labor cost per hour	$15		
KW	500 per hour	2,250,000	
Cost per KW	$0.04		
Tons per year Compost		27,000	
Tons per year raw material		32,400	
Moisture reduction	20%		
Interest rate	13%		
Depreciation period years	7		
Royalty per ton	$5		
FIXED COST			Per ton product
Capital cost	PMT formula	$205,761	$7.62
Maintenance. (on investment)	4%	$32,000	$1.19
Insurance(on investment)	2%	$16,000	$0.59
Overhead on operating cost	20%	$92,100	$3.41
TOTAL FIXED COST		$345,861	$12.81
OPERATING COST			
Power		$90,000	$3.33
Labor		$202,500	$7.50
Fuel for loader and forklift		$6,000	$0.22
Royalty		$162,000	$6.00
TOTAL OPERATING COST		$460,500	$17.06
TOTAL COST FOR COMPOST		$806,361	$29.87

Figure 9

EXPENSES BREAKDOWN

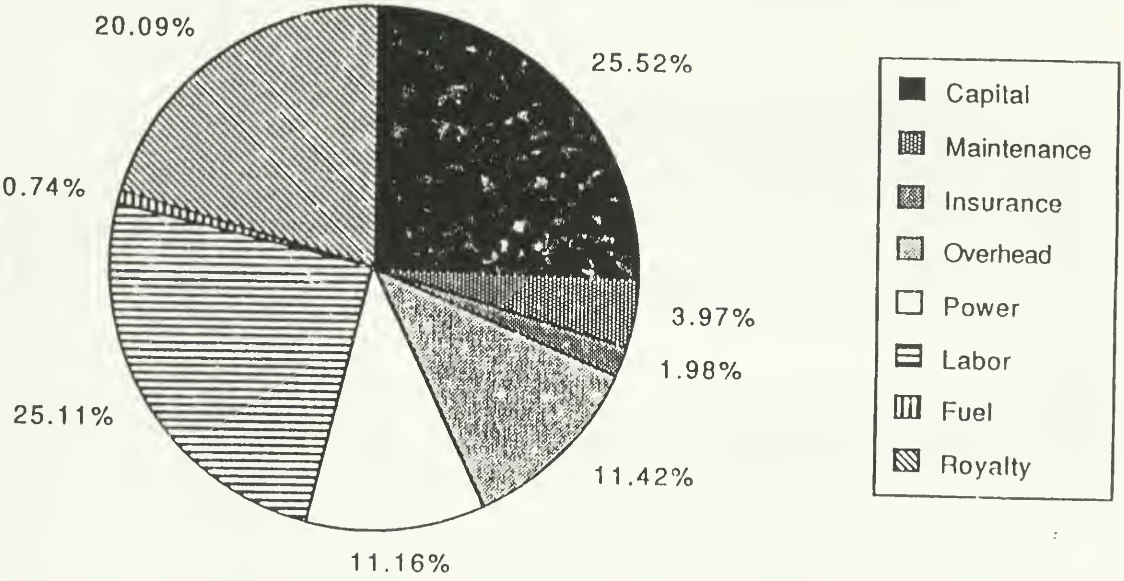


Table 6

EFFECT OF NUMBER OF WORKING HOURS

Hours	Cost	Tons
3000	$35	21,600
3200	$34	23,040
3400	$33	24,480
3600	$32	25,920
3800	$32	27,360
4000	$31	28,800
4200	$31	30,240
4400	$30	31,680
4600	$30	33,120
4800	$29	34,560
5000	$29	36,000
5200	$29	37,440
5400	$28	38,880
5600	$28	40,320
5800	$28	41,760
6000	$27	43,200

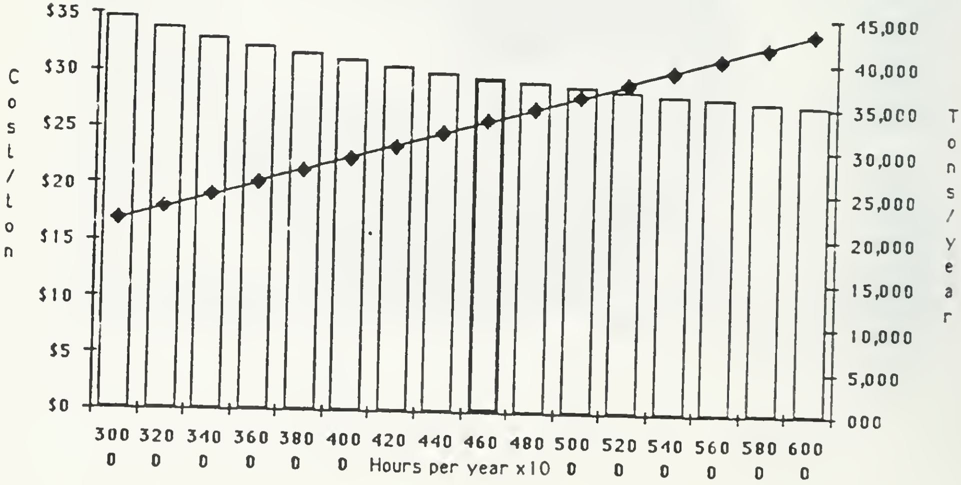
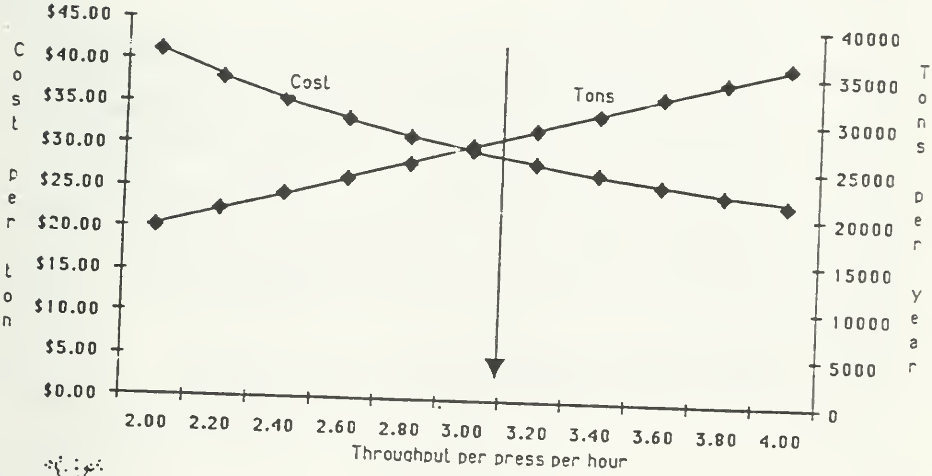


Table 7

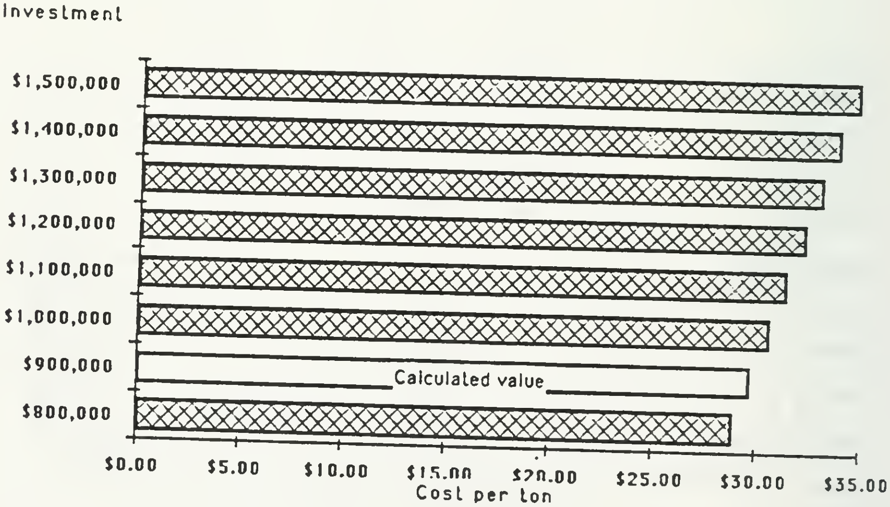
EFFECT OF THROUGHPUT OF THE PRESS ON THE COST

Throughput	Cost per ton	Tons per year
2.00	$41.20	18000
2.20	$38.11	19800
2.40	$35.53	21600
2.60	$33.35	23400
2.80	$31.48	25200
☞ 3.00	$29.87	27000
3.20	$28.45	28800
3.40	$27.20	30600
3.60	$26.09	32400
3.80	$25.09	34200
4.00	$24.20	36000



EFFECT OF THE INVESTMENT ON COST

Investment	Cost per ton
$800,000	$28.94
$900,000	**$29.78**
$1,000,000	$30.62
$1,100,000	$31.46
$1,200,000	$32.29
$1,300,000	$33.13
$1,400,000	$33.97
$1,500,000	$34.81



7 MUNICIPAL GARBAGE PROCESSING

7.1 Introduction

The operation at Brimley Recycling generated a portion of municipal type garbage as construction sites trashed materials such as their lunch wastes into the disposal containers. This material ended up in the portion of waste landfilled but was suitable for additional processing by the ATS-TSP either into a densified dried logs or as a granulate. Tests were carried out to demonstrate the potential of the ATS-TSP to perform both functions. The advantage of the machine processing this waste before landfilling is that of turning the garbage into a dried and more densified state. A recycling site can then hold greater volumes in less area, remove moisture to decrease shipping weight, and dry the waste to arrest decomposition. The material will additionally reduce shipping and tipping charges at the landfill site due to lower weight from moisture removal and takes less space to bury.

7.11 ATS-TSP Garbage Processing

The results that can be achieved from the ATS-TSP in processing a waste vary according to the characteristics of the material processed. General experience with municipal type garbage, which is predominantly made of light materials, such as cellulose, organics and plastics, is as follows.

Feedstock used	Mixed garbage predominately papers (photo 21), plastics, foods, with miscellaneous solid objects such as cans, rocks etc.
Garbage moisture	30 percent average
Driving power	150 kw.
Discharge output (average)	Briquetting 900 kg/hr Granulating 1800 kg/hr
Screw speed	81 rpm
Finished product	Dense briquette with an average moisture content of 15 percent or flaked material
Volume reduction	Average 7:1 Range can be as high as 10:1

These results can vary as the specific gravity and friction characteristics do differ with loads. Tests were carried out on the general municipal type garbage. This waste came from street pickup, commercial building pickup, and airport garbage. All waste sources were predominately paper, cardboard, plastic, food and a small percentage of recyclables such as cans or glass. The work carried out on these wastes demonstrated the above average production rates were dependant on variables such as the following.

Production:

The ATS-TSP needs an even flow of waste into the intake hopper to maximize production. Variations due to uneven feeding decrease the production rate of the machine. For this reason it is best to preshred the waste to get an even flow rate.

The moisture content of the garbage affects production. Feedstock with wet clumps of food waste. with greater than 70 percent moisture, slow down production when briquetting to drive off the concentrated batch of water. An even blend of garbage allows friction producing material such as paper/cardboard to generate the friction heat required to drive off the moisture (photo 22). Thus preshredding again benefits the operation through the blending of the wet and dry garbage. Best densification rates were achieved with waste having an average moisture content of below 35 percent.

Labour:

Garbage densification requires a minimum of two people to run one ATS-TSP, as the garbage needs to be continuously monitored for flow and foreign objects. The second labour unit is required to run the machine and off load briquettes.

Maintenance:

Maintenance costs are generally higher with garbage as the waste because it is unpredictable in content. Non magnetic and other alloy materials are difficult to detect and passed through the machine. The tolerance of the ATS-TSP to foreign objects is high due to the screw type processing concept that allows the screws to absorb the piece of material between the flights and pass it under the friction plate and out of the machine. Large bolts and knives have carried through the machine without any slow down in production but they do damage the hard facing on the screws thus increasing the frequency needed to reface the parts. Glass and rocks found in the garbage crush relatively easily with this machine but the abrasive nature of the glass will again increase the number of times that the machine needs to be maintained.

High wear factor materials are calculated into the machine maintenance program and the screws will need to be rebuilt on a more regular basis.

7.12 Preliminary tests on Municipal Garbage using the ATS Model 3T

Spider's first tests running garbage were carried out on the small motor ATS-TSP. The findings were as follows:

Waste content The garbage consisted predominately of papers, plastic and food waste with miscellaneous wood, glass, metal cans and textiles. The moisture content varied between 25 and 35 percent.

Processing The garbage was fed directly into the machine without shredding and the ATS screws readily accepted and drew small bags of garbage into the machine, disintegrating the products as it went, providing that there was a corner for the screws to catch. The

Photo 21. **Mixed garbage being processed into Refuse-Derived Fuel (RDF)**

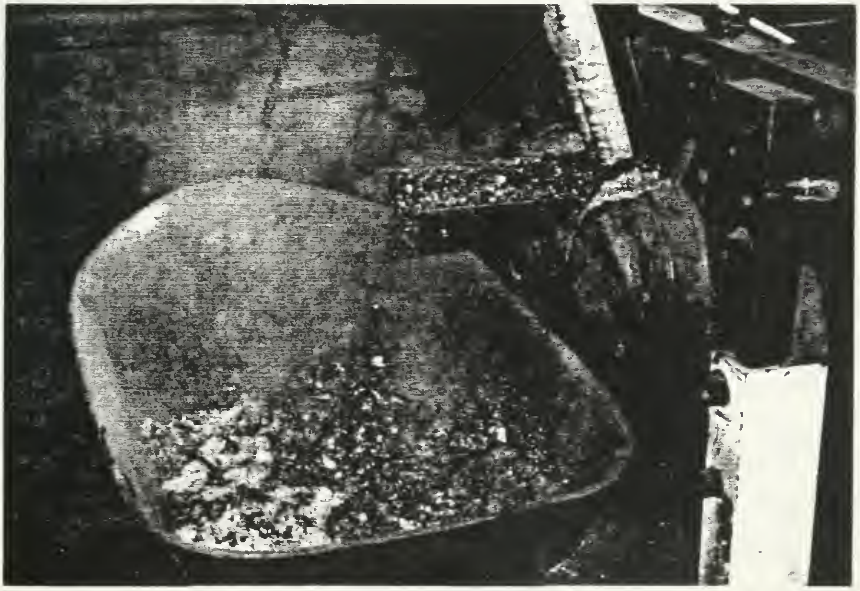
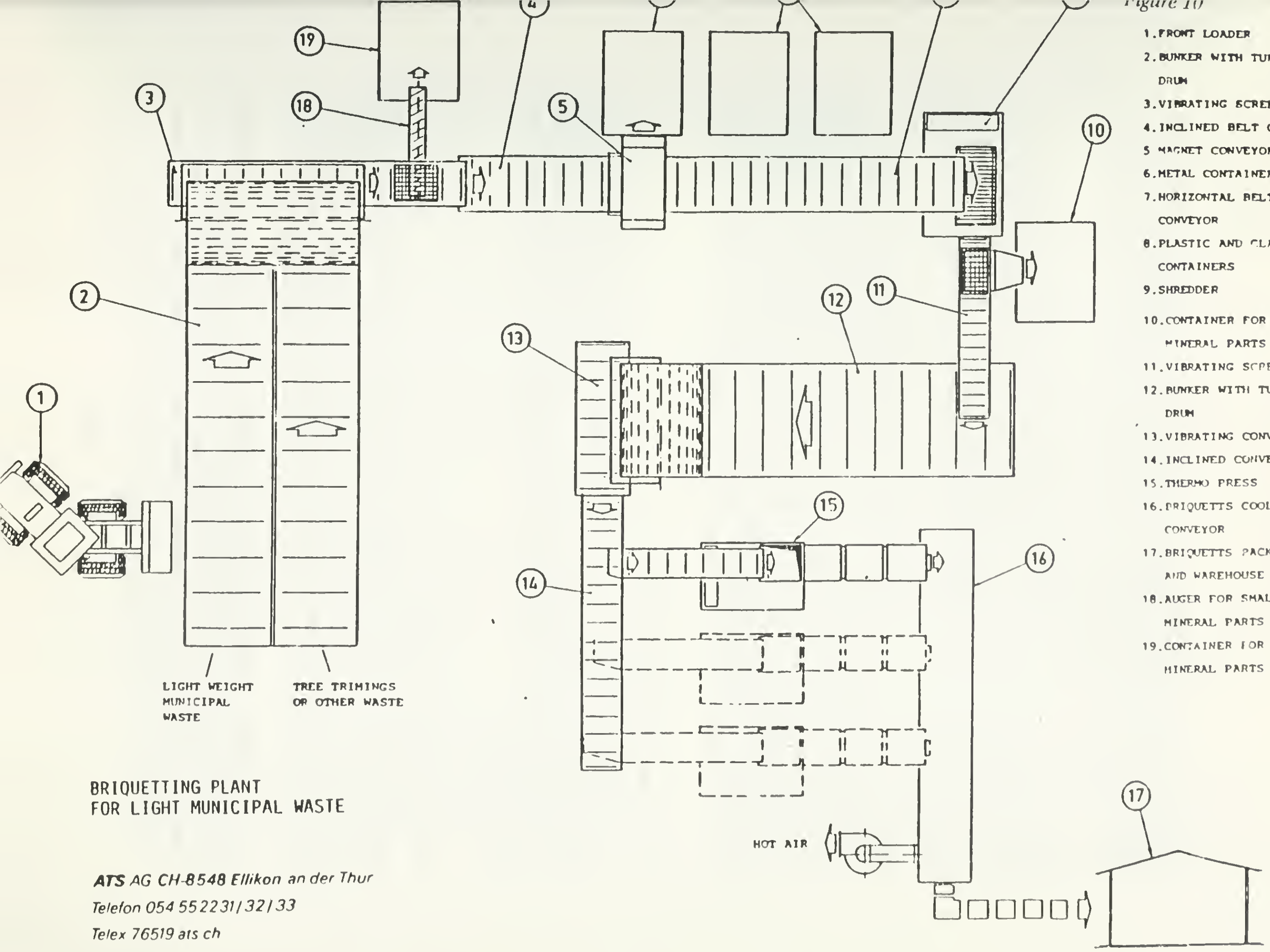


Photo 22.
The garbage heats up from friction created in the machine and the temperature rises over the boiling point of water, resulting in drying and pasteurization of the garbage.

Figure 10



1. FRONT LOADER
2. BUNKER WITH TURNOVER DRUM
3. VIBRATING SCREEN
4. INCLINED BELT CONVEY
5. MAGNET CONVEYOR
6. METAL CONTAINER
7. HORIZONTAL BELT CONVEYOR
8. PLASTIC AND GLASS CONTAINERS
9. SHREDDER
10. CONTAINER FOR SMALL MINERAL PARTS
11. VIBRATING SCREEN
12. BUNKER WITH TURNOVE DRUM
13. VIBRATING CONVEYOR
14. INCLINED CONVEYOR
15. THERMO PRESS
16. BRIQUETTS COOLING CONVEYOR
17. BRIQUETTS PACKAGING AND WAREHOUSE
18. AUGER FOR SMALL MINERAL PARTS
19. CONTAINER FOR SMALL MINERAL PARTS

BRIQUETTING PLANT
FOR LIGHT MUNICIPAL WASTE

***ATS** AG CH-8548 Ellikon an der Thur*
Telefon 054 55 22 31/32/33
Telex 76519 ats ch

limitation to direct feeding is the small 60 cm by 60 cm intake hopper and that round containers would just roll on the top of the screws. This problem is overcome by preshredding. The ATS-TSP had no trouble achieving a 7:1 densification. The polyethylene plastic in the waste melted and would coat the surface of the extruding log thus helping to seal the surface and act as a binder.

Production rates The ATS-TSP Model 3T densified the waste at rates from 500 kg to 1000 kg/hour. This machine had the smaller 270 hp diesel motor. It was discovered that very wet waste such as diapers would be too wet to allow a log to form. Preshredding and mixing helps to overcome this problem. Wastes with a moisture content of up to 35 percent densify very well provided that there is sufficient friction producing content in the waste such as paper type materials.

Densification/weight reduction Two 30 cubic meter containers of uncompacted commercial waste were processed through the ATS-TSP into granulate and densified on an estimated 6:1 ratio. Smaller tests on municipal garbage direct from the streets densified consistently on a 7:1 basis. Moisture loss due to processing was significant with both tests and estimated to exceed 10 percent of the weight of the waste. It was observed that much of the moisture is lost after the waste leaves the machine. Both densified and granulated garbage should be allowed to air for 30 minutes as moisture continues to be released from the product as the heat from processing is still retained in the particles. The addition of a small air chamber following the machine is necessary to achieve the desired results.

7.13 Garbage Flaking and Densification

It has been demonstrated how variable garbage can be. Certainly the wastes from construction sites is different than commercial wastes or household refuse. Specialists brought from Switzerland during the development period thought that some of the samples were the worst garbage they had ever processed. This all affects the systems approach to recycling and the need for presorting or processing of the waste material before the ATS-TSP operation.

7.2 Airport Garbage Introduction

During the period of Spider's developmental project with the ATS-TSP a project developed at the Lester B. Pearson International Airport at Toronto, to densify garbage which provided an opportunity for researching the ATS-TSP. The Metropolitan Toronto municipal government decided to shut down their antiquated local solid waste incinerator that because of its air emissions was a potential health problem to local residents.

This relatively quick decision left the airport officials with a crises in dealing with their garbage during the summer of 1988. Regulations for international airports require the burning or sterilization of the waste. This is because of the real prospects of international germs that may infect livestock and adversely affect Canadian farms and image as a provider of quality agricultural products.

Since there was no acceptable place to burn the waste on short notice, the officials gave Econolier Inc. of Montreal a contract to establish an emergency research facility at the airport site using the ATS-TSP. This approach was to shred the solid wastes and in one operation dry and densify the material. This was to allow for storage and later shipment for disposal or combustion. The work developed into additional sterilization for garbage.

7.21 Airport Solid Waste Processing

The operation had very short notice to set up and great start up difficulties arose. These included the already accumulated and growing inventory of airport garbage. It was hoped that one or two of the ATS-TSPs would be able to process the material. Unfortunately breakdowns and lower than expected throughput of the machines aggravated the crises.

It was found that there was a requirement to separate out the metal from the garbage. This problem also resulted in hundreds of flat tires for the front end loaders involved. Unfortunately the waste was a wide range and unpredictable flow of material that even included the occasional airplane part that had fallen off on the runway. Other waste was food stuffs from the meals on the planes and the food services groups at the airport. These food materials tended to have high moisture contents and this variable flow of material could not adequately be processed to a densified form. Furthermore generally exposed wastes got drenched by rain awaiting processing. This added problems to the ATS-TSP process.

To try to keep up with the buildup of material further equipment was arranged by Econolier to shred the waste, separate the metal and better convey and transport the material at the site. To augment the team Spider's portable ATS-TSP was made available.
Operators of the Spider portable ATS-TSP machine at the airport site (photos 3, 23) found that the best that they could process on average to a densified form (photo 24) was 600 kg/hour. The up time on the system was not very good during the period before the additional shredding and metal separation systems were installed.

To continue to try and stay ahead of the crises by gaining greater throughput Econolier chose to mainly flake the material to try to stabilize it for storage in trailers and roll off boxes that were rented. It was more compact and stable flaked than in the bulk storage. To help alleviate the sanitation and public relations problems a decision was made by airport officials to ship the waste to Buffalo for combustion. This then made the test facility mainly a transfer station to handle the waste.

7.22 Airport Garbage Waste Processing System

Steps were taken to design and install a system at the airport to process the waste (following analyses prepared for Spider-Maple Lift) and government officials concluded that the ATS- TSP under proper conditions can sterilize certain waste materials (appendix 2). ATS as a result of these experiences is considering a new generation of the ATS-TSP that can, in one pass process, completely sterilize and densify were necessary infected solid wastes. Potential users include the airports and hundreds of hospitals that every day must dispose of infected materials.

Photo 23. Mixed shredded garbage is fed into the ATS mobile machine

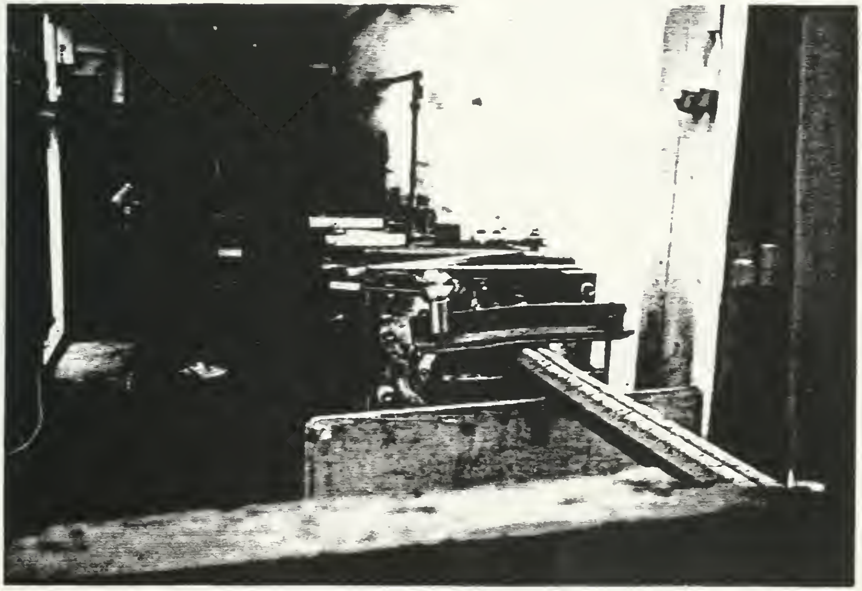


Photo 24. Garbage *(as shown in photo 23)* densified into a continuously-extruded log

AIRPORT WASTE-COST ANALYSIS

Table 9

5-Feb-90			
INVESTMENT			
Feeding conveor	$25,000		
Complete installation	$850,000		
Hauling bin	$10,000		
Heating tunnel	$40,000		
TOTAL	$925,000	$96.35	
DATA			
Number of Presses	1		
Royalties per ton	$10		
Operating hours per year	4800		
Capacity of press.Tons per hour	2		
Weight reduction	20%		
Number of Workers per shift	2		
Number of shifts	2		
Labor cost per hour	$15		
KW	250	1200000	
Cost of KWH	$0.08		
Tons per year input and output	9600	7680	
Volume reduction	1/7		
Interest rate	12%		
Depreciation period(years)	7		
Maintenance	4%	on investment	
Insurance	2%	on investment	
Heating energy	30	$0.46	$66,240
FIXED COST	Per year		Per Ton
Capital cost	$202,684		$21.11
Maintenance	$37,000		$3.85
Insurance	$18,500		$1.93
TOTAL FIXED COST	$258,184		$26.89
OPERATING COST			
Power	$96,000		$10.00
Labor	$144,000		$15.00
Fuel	$66,240		$6.90
Royalties	$96,000		$10.00
TOTAL OPERATING COST	$402,240		$41.90
TOTAL COST	$660,424		$68.79

8 TIRE PROCESSING

8.1 Tire Introduction

Spider's various customers did not have many tires to dispose of yet some would end up in the roll off boxes from customers, employees and neighbors. However with the tires being a fairly consistent waste product that could be available, trials were done to consider the application of processing them with the ATS-TSP.

To start off, many of the truck tires are currently reused and recycled so that the Spider efforts were aimed at passenger tires that may be available from new replacement tire dealers and service stations.

8.2 Rubber Crumbing

The ATS-TSP is not now designed so that a whole tire could be fed into it. Tires were shredded so that they, like many of the other materials, could better flow into the unit for processing. The initial absence of a proper shredder at Brimley Recycling made the initial testing limited to shredded material from outside sources. This material was often wide ranging in size and shape which caused problems to the Brimley Recycling ATS-TSP research.

It was found that the ATS-TSP could process the shredded tires, especially if they were 5 cm minus in size. Processing was aimed at the liberation of the rubber from the metal steel belting and beading. This rubber fraction contained much of the fiber component of the tire. The metal was not completely cleaned of the rubber and as such in the initial tests was stockpiled for future reprocessing.

In fact tire processing proved to be an interesting application for the ATS-TSP technology. It is a solid waste material that can be separated at source or brought to a processing or storage area. The hundreds of Canadian stockpiles and the over one billion tires stockpiled in North America have highlighted this convenience of supply and collection for economic processing systems.

8.3 Tire Processing Problems

The problem was to separate the tire into its three main components: metal, rubber compounds, and fiber. Each is recyclable if it can be separated. One area is to separate or liberate them from the tire. The next is to do that in a manner that will provide a flow of separated "reasonably pure" materials.

We found that the ATS-TSP could process shredded tire material by liberating the components. There are surge hopper bridging and feeding problems, as with the other solid waste materials to gain access to the twin screw feed and processing zones of the machine. This is partially rectified by getting a consistent supply of 5 cm minus shredded material as it is conveyed to the ATS-TSP. This consistency is limited by the inadequacy of most of the tire shredding systems to process the whole tires on a cost efficient basis to consistently sized tire chips. The smaller the tire chips are the better they tend to flow and the less machine work required to further reduce them in size and liberate the various components. During the Spider tests it was still important to have a person monitoring the input shredded tire chips, to minimize any tramp metal and other foreign material. Throughput of the tests ranged any where from 1 tonne to 3 tonnes per hour depending on the size of the shredded tire pieces and the crumb rubber product sizes and metal cleanliness required. Crumb rubber specifications require a relative purity of material. That is they don't want "someone's lunch' or garbage thrown into the processing system, and contaminating their rubber feedstock.

Other initial problems included the heating of the processing zone and the tire chips from the ATS-TSP operating action. The machine effort required to process and the difficulty and friction to liberate the tire components created excess heat. This potential overheating in the machine work zones during the Spider tests sometimes caused gaseous emissions that could affect the working area. As well the heat and violent processing approach sometimes produced certain weaknesses in the further processing characteristics of the rubber fraction after it was separated.

8.4 TWR Proposal

TWR has made a cost shared proposal for project funding with the MOE (last proposal dated May 8, 1989). They have undertaken that research and development project separate from the initial Spider research. Generally TWR has made efforts in their project to cool down and improve the processing by various approaches including water cooling jackets, liquified nitrogen. water injection into the processing zone, air injection into the processing zone and adjustments to the processing speed and screw flight patterns. Further designing and testing was also done to improve the overall system's ability to separate the crumb rubber, fabric and metal.

8.5 Tire Markets

As far as marketing is concerned tire products are relatively simple yet complicated. Many potential buyers of recycled rubber material will only accept the material if it is free of the steel belted and metal bead material. This metal separation was not adequately accomplished with the limited Spider tests. Tire steel is a high carbon material that, if cleaned of rubber, can be sold directly to the metal recycling industry. Some rubber buyers can utilize some fiber in the rubber material, nowever this fiber must still be substantially in the form of the lengthy fibers in the tire. Certain of the early tests produced fibers that were "short fuzzies" and less useful for certain recycled product efforts.

Generally there needs to be a more concerted effort on the part of government and industry to expand the actual demonstrations of applications (table 14) for most types of the tire components.

As noted TWR has entered into a multi-million-dollar effort to solve these potential tire related problems and has since set up a demonstration processing plant at Brimley Recycling for testing and ongoing processing, production and marketing operations.

8.6 TWR Tire Processing Results

To supplement the information in this Spider-Maple Lift Limited report, TWR has provided on our behalf the following recent actual production figures for their research, development, and demonstration 3 ATS-TSP tire processing facility, at Brimley Road, in Scarborough, Ontario.

COST AND PROFIT ANALYSIS

Table 10

DATA	Per hour	Per year	Data
Processing of raw tires- tons	3.2	16000	320 tires
Throughput of crumbs <8 mesh and threads	1.59	7968	60%
Throughput of crumbs 1/4" and threads	1.06	5312	40%
Total throughput crumbs	2.66	13280	
Loss (non marketable material)			5%
Percentage of steel			12%
Operating hours in 3 shifts. 20 hours per day		5000	
Number of Thermopresses			3
Number of workers per shift	3	15000	
Technical manager (one shift)	1	2000	
Cost of labor	$15.00	$225,000	
Cost of manager	$36	$60,000	
Consumption of power. KW	600	3000000	$210,000
Cost of KW	$0.07	$210,000	
Investment as per attached sheet			$2,070,000
Interest rate			12%
Royalties payment. Dollars per ton crumbs	15.00		$199,200
Depreciation period of equipment(years)			7
Insurance (percentage on investment)			2%
Maintenance (percentage o investment)			4%
Price for <8 mesh crumbs	Per ton		$150
Price for 1/4" crumbs	Per ton		$100
Price for composite crumbs	Per ton		$130
Price for steel	Per ton		$50
Tipping fee for tires	Per ton		$60
Overhead. Percentage of variable			10%

FIXED COST			Per Ton raw	Ton crumbs
Capital cost on investment(PMT)		$453,574	$28.35	$34.15
Insurance		$41,400	$2.59	$3.12
Maintenance		$82,800	$5.18	$6.23
Overhead		$69.420	$4.34	$5.23
Lease of land and building		$100,000	$6.25	$7.53
TOTAL FIXED COST		$747,194	$46.70	$56.26

VARIABLE COST				
Labor		$225,000	$14.06	$16.94
Technical Manager		$60,000	$3.75	$4.52
Energy		$210,000	$13.13	$15.81
Royalties		$199,200	$12.45	$15.00
TOTAL VARIABLE COST		$694,200	$43.39	$52.27

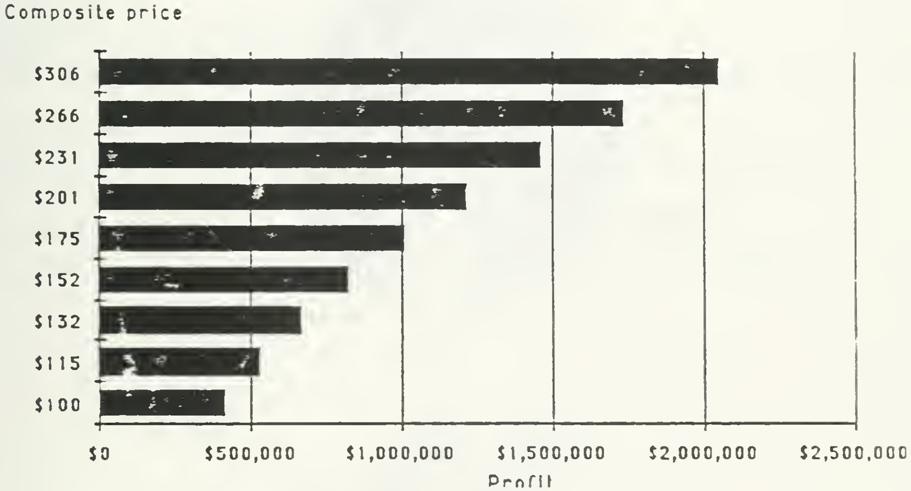
TOTAL COSTS		$1,441,394	$90.09	$108.54

INCOME				
Crumbs (composite)		$1,035,840	$64.74	$78.00
Steel		$96,000	$6.00	$7.23
Tipping fee		$960,000	$60.00	$72.29
TOTAL INCOME		$2,091,840	$130.74	$157.52
PROFIT		$650,446	$40.65	$48.98
Net cost(after deduction of steel and tipping)				$29

Table 11

EFFECT OF THE PRODUCT PRICE ON PROFIT

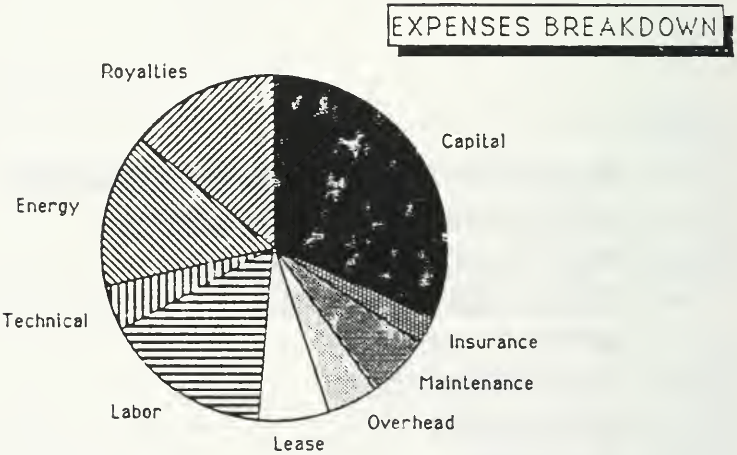
Price of crumbs	Profit
$100	$411,406
$115	$530,926
$132	**$668,374**
$152	$826,439
$175	$1,008,214
$201	$1,217,256
$231	$1,457,653
$266	$1,734,110
$306	$2,052,036

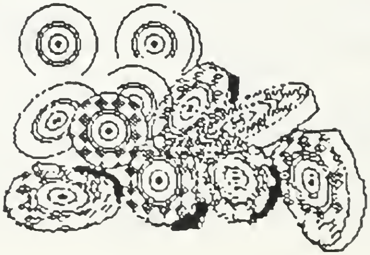


BREAKDOWN OF COSTS

Figure 11

Paragraph	Cost per ton	Percentage
Capital	$34.15	31.47%
Insurance	$3.12	2.87%
Maintenance	$6.23	5.74%
Overhead	$5.23	4.82%
Lease	$7.53	6.94%
Labor	$16.94	15.61%
Technical	$4.52	4.16%
Energy	$15.81	14.57%
Royalties	$15.00	13.82%
TOTAL	**$108.54**	**100.00%**





INVESTMENT LIST

Table 12

EQUIPMENT	Numb.	PRICE	CODE REF.page 11
ATS 2-300-2T-1	1	$350,000	24
ATS 1-300-3T	1	$400,000	4
ATS 2-300 3T/E-1	1	$400,000	18
Electric & hydraulic panel	1	$20,000	1
Multidec vibrating screen	2	$25,000	6-6A-20
Magnet	4	$50,000	22-26-10-35
Feeding bin	2	$50,000	2-16
Storage bin	2	$30,000	29-11
Shredder	1	$200,000	
Cooling unit	1	$25,000	
Conveyors	7	$20,000	3-5-25-17-15-23
Augers	5	$40,000	7-21-19-30-9-8-27-31
Blower and packaging	1	$10,000	12-14
Miscellaneous		$150,000	
Installation		$300,000	
TOTAL		$2,070,000	

All prices are an estimate, based on the present values.
Prices include supervision of assembly, start-up of the installation and training of customers technician on site.
Allowance of the technician will be covered by the customer.
Price also includes a package of spare parts for the ATS machines.

Table 13

MOTORS SPECS-TIRES PLANT

MODEL	MOTOR TYPE	# MOTORS	NOM HP	MEASURE AMP	CALC. KW	CONV.FACTOR	VOLTS	NOM KW
2-300-2T	Unity +	1	125	85	98	0.78	550	97.5
2-300-3T	Unity +	1	250	175	201	0.80	550	195
2-300-4T	Regular	2	100+100	165	189	0.95	550	128.7
TOTAL PRESSES		4	575	425	463	0.81		421.2
Shredder		1	100				550	78
Compressor		1	50				550	39
Hydraulics		1	30				550	23.4
Aux motors		1	40				550	31.2
TOTAL AUX.		4	220				550	171.6
TOTAL		8	795					592.8

1.The model refers to the type of the ATS Thermopress.
2.The Unity + type is a special winding design which improves the capacity of the motor.
3.NOM HP is the nominal spec of the motor
4.The measured AMP is the average reading of the Amperage during the operation of the system
5.The calculated KWH is : (V X A X power factor x 1.732)/1000
6.The nominal KWH is a multiplication of the NOM HP by 0.75
7. The power factor is: KW/(V X A X 1.732)
8. The coversion factor is calculated as: Calculated KW devided by the NOM HP

POTENTIAL USES FOR RECYCLED RUBBER

Table 14

1. Playground and recreation areas
2. Athletic tracks
3. Swimming pool surrounds, garden paths
4. Flooring tiles
5. Carpet underlay
6. Barn mats and livestock floors
7. Car, door and sports mats
8. Rubberized asphalt for roads and driveways
9. Base for horse racing tracks
10. Subsoil drainage
11. Drainage pipes
12. Pipe insulation and lining
13. Waterproofing compounds for roof and walls
14. Foundation waterproofing
15. Shock absorbing pads for rails and machinery
16. Sound barriers for motorways
17. Adhesives and sealing compounds
18. Textured and nonslip paints
19. Car body underseal. rustproofing materials
20. Compounding ingredient(filler) for many rubber mouldings and extrusions
21. Filler in many plastic mouldings and extrusions
22. Car and truck splash and mud guards
23. Abrasion lining in mining equipment
24. Garden hose
25. Casters and other solid wheels
26. Flower pots
27. Garbage cans
28. Soil conditioner
29. Filtering agent (mercury and metallic sulfides)
30. Shoe soles and heels
31. Wire and cable insulation
32. Industrial and agricultural tires
33. Conveyor belting and repair compounds
34. Expansion joint compounds
35. Porous irrigation pipes
36. Dam, silo, and roof liners
37. Nonslip boat deck surfaces
38. Conveyors idlers and liners
39. Car and docks bumpers
40. Loading and off loading liners

9 DRYWALL WASTE

9.1 Introduction

When buildings are constructed a significant amount of the structure is walled off with drywall, a fire proof material made of gypsum (calcium sulphate) and paper. A portion of the construction waste contains sheets of this waste and it was separated out into a storage pile. Drywall causes problems at dumps through water contamination and also in incinerators from the high sulphur content. It is therefore important to find recycling solutions. The key to the usefulness of the ATS-TSP is that any recycling station will get a portion of drywall. After separation this could be sent direct to a drywall recycling centre or processed on site using the machine and sold in powder form.

9.2 Drywall Research and Demonstration Work

R&D work with the ATS-TSP demonstrated the machine will breakup and grind to powder the drywall. Settings on the machine can be adjusted to allow extraction of the major portion of the paper if this is required. If all the drywall is ground up the powder product will analyze having over 85 percent gypsum, 5-10 percent cellulose (paper) and the rest inert ingredients. This material can be used in 5 percent blending to make new drywall if the analysis of the gypsum is satisfactory.

Higher gypsum content of the powder was achieved through grinding so that the paper was not ground into the product but came out in flakes. These flakes were then screen separated from the product. The flakes can then be mixed in with asphalt materials as a filler. The gypsum blending with the asphalt was tried and proved to increase the compaction strength of the bitumix product.

The gypsum powder was tried as a construction product in the mixing with non specification cement to decrease its cost. This resulted in lower strength of the cement but with more testing may have certain applications where the strength of the cement is not the major factor. An example might be for containment applications. The product was also tested as unshrinkable fill. These tests demonstrated that the product had the properties so that it might be used for these purposes. Other possible uses for the gypsum powder include agricultural applications for alkaline soils and as an additive to asphalt tiles.

9.3 Processing Considerations

The throughput of drywall in the ATS Model 4T 110 kw was calculated to be 3 tonnes per hour (photo 26). The newer machines may be able to do more. Production rates are higher processing this material verses organic feedstock due to the high specific gravity of gypsum. A projected profit analysis prepared by TWR for Spider-Maple Lift follows.

Spider through its disposal clientele had access to variable quantities of this material. Problems involved pad separation, crushing and processing. The material tends to be variably sized chunks. These large pieces are easily separated at the pad but require storage (photo 25) and subsequent size reduction for processing in the ATS-TSP by a shredder.

Problems include the availability of consistent supplies of this type of material for ongoing processing. In order to get consistent supplies it may be necessary to close the material off from the various private and municipal landfills.

The main markets are the reusing for reprocessing of the materials. Unfortunately the manufacturers of drywall tend to set up on sites that provide gypsum from underground sites for about $10 per tonne. With transportation it makes it difficult to recycle the drywall and compete without nigh tipping fees.

Photo 25. Inside Drywall Storage

Photo 26. Gypsum Powder Production from Drywall Waste
Two men separating paper from screen in pilot drywall operation.

DRYWALL PROJECT ANALYSIS

Table 15

DATA	5-Sep-89	
Total amount of raw material per year	15000	
60% of raw material moisture content	40%	
40% of raw material moisture	5%	
Finished product moisture	5%	
Tons finished product	12900	
Capacity per hour finished product	2.5	
Capacity per hour input	2.91	
Operators per shift	1	
Cost labor per hour	$20	
Cost power $/kw	0.04	
Power consumption KW per hour	250	
Depreciation period yrs	5	
Interest rate	13%	
Royalties payment per ton	$8	
Extra investment by user	$200,000	
Insurance	2%	
Maintenance	4%	
Number of working hours	5160	
Cost of ATS TSP	$400,000	
FIXED COST	Per year	Per ton
Capital cost on investment	$113,726	$7.58
Insurance	$12,000	$0.80
Maintenance	$24,000	$1.60
Total fixed cost	$149,726	$9.98
OPERATING COST		
Power	$51,600	$3.44
Labor	$103,200	$6.88
Royalties	$120,000	$8.00
Total operating cost	$274,800	$18.32
TOTAL COSTS	$424,526	$28.30
Saving		
Trucking and landfill	$750,000	$50.00
Recycled material	$129,000	$10.00
Total	$879,000	$58.60
Total Saving	$454,474	$30.30

16 PLASTIC PROCESSING

High density, low density, pre consumer, post consumer, no consumer, there are so many types of plastic. It ranges from 100 percent of the same type to many variations from scrapped automobiles. How to process it is the general concern that is combined with what uses the plastic can be diverted to.

The ATS-TSP appears to have potential for processing various plastics. Once separated the plastics materials can generally be fed into the ATS-TSP, for processing. The unit then mixes the feedstock while heating it up for extrusion into composite products. What products is part of the problem for the mixed recycled plastic materials.

The ATS-TSP tests generally showed that various plastics materials could be processed or blended into an extruded plastic form. The form depended on the shape of the die at the exit end of the machine. Temperatures go well above 150 degrees C. with plastics extruding as there is no moisture to vaporize and cool the machine. Blending fillers such as waste wood can help overcome this. The material could be extruded into variable shapes such as posts or other forms.

In some cases the plastic was mixed with sawdust type material and the resulting material was an interesting blend of recycled material. TWR has also done some testing on its own that shows promise for using plastic to encapsulate other wastes such as shredded "fluff" (which contains plastic and fibers) remaining after scrap automobiles are shredded. This makes the fluff waste easier to handle, truck and dispose of.

Additional concentrated research and development are required to identify the complete range of uses and products from processing plastic with the ATS-TSP. In the meantime densifying the plastic allows for easier trucking and disposal at landfill sites.

Although the ATS-TSP can process plastic, the amount of plastic waste that was found in the construction material was minimal. As there is already an established industry recycling plastic, the baling and delivery of separated plastics to these businesses appeared more economic as is the case with separated cardboard. However the preliminary research demonstrated that the ATS-TSP can both process the plastic waste to extrude products (when the temperature is regulated) or in containment applications to encapsulate a more hazardous waste such as asbestos.

Table 16 provides a list of possible applications or uses for recycled plastic.

PRODUCTS MADE FROM RECYCLED PLASTIC BOTTLES

-Fence posts
-parking space bumpers
-Furniture
-gates

-Horse stalls
-fruit tree supports
-tree-guards
-erosian control timber

Lumber subsitute for:

-boat piers
-pig and calf pens
-outdoor furniture, litter recepticles and signs
-garden furniture

-flower pots
-traffic barrier cones
-trash cans
-signs
-board walks
-lobster traps
-road delineators
-fences
-landscaping timbers
-fences, gates, enclosures
-garden boundary retainers
-playground equipment
-storage bins
-picnic tables
-highway construction
-slab separators
-footings, posts and sill plates.

-pier impact protectors
-dock side fenders
-boat docks
-rub rails
-fishing boat wear plates
-beach erosian control
-barriers
-traffic direction posts
-compost enclosures
-retainer walls
-park benches
-sand box kits
-golf course walk ways
-flower and tree boxes
-markers
-truck flooring

maple lift

11 ROOFING WASTE

11.1 Introduction

This material is becoming more difficult to dispose of. A demonstration was undertaken to make use of the bitumen content of the waste and mix the material together to make some type of roofing or road base. It was found there was predominately two types of asphalt roofing that were disposed of. First asphalt shingles and second flat roofing where the roof is made up of paper covered with tar and finally pea gravel.

11.2 Roofing Shingles

These were found to process relatively easily. The waste that came into the yard was 95 percent shingles and required little picking to clean up (photo 27). As the shingles were irregular in size it was found necessary to break down the pieces in a hammermill to 10 cm chunks and then feed them into the ATS-TSP. The shingles were then ground up by the ATS and heated at the same time to a melting point where all the components homogenized together and a thick pliable bitumix extruded from the end of the machine (photo 28). Tests were carried out to mold blocks from this hot material and it was discovered that the product could then easily be molded into many forms.

The strength of the material is high because of the fibers in the composition and the bitumen would go solid within an hour depending on the thickness of the product made. Large objects take much longer to cool due to the lower product to surface area ratio.

11.3 Flat Roofing

This material requires more handling as it will be larger in size and requires the pea gravel to be separated from the paper. This was carried out by passing the waste through a hammermill powered by a 400 hp diesel, and shredding the waste. The product that came out had the majority of the pea gravel knocked off the paper. This material was put over a shaker screen and the gravel separated from the bitumen.

The remaining paper and bitumen with a small percentage of gravel was fed through the ATS-TSP and homogenized. The machine caused the asphalt in the roofing material to liquify due to the frictional heat buildup. This allowed a homogenization of all materials fed into the press, thus allowing all undesired contaminants to become blended forming a uniform "bitumix" material that potentially can be used as a base in many products using asphalt bases. The machine easily ground up the remaining gravel into fine pieces.

One problem found with processing roofing materials is that in the summer when temperatures get high the ability of the hammer mill to break the gravel off the roofing material decreases as the brittleness of the waste is completely lost.

11.4 Product

The bitumix material was tested as a potential material for use in the reroofing trade. The product was melted in a tar pot to observe the possibilities. It was found that it was possible to use but provided more difficult working conditions for the roofer as the heating temperature was more critical as organic materials in the bitumix would begin to oxidize. Also the stone particles tended to separate and move to the bottom of the pot requiring continuous agitation if the product was to remain uniform. Where applied the product appeared to have good sealing abilities and with a low selling price could be used for reroofing.

The bitumix material can also be used for fuel, paving blocks and tiles as well as a feedstock for paving material.

Table 17 is an economic analyses, prepared by TWR for Spider-Maple Lift, of the processing of roofing waste. The ATS-TSP will process 3 tonnes/hour of roofing waste. Based on an operation running 7500 tonnes per year it will cost an estimated $84 per tonne to process this waste. Note this is a costing based on the equipment only and no facilities. Heavier waste is more economic to process as the production capacity of the machine is higher. As the processed material is anticipated to have a significant value this application should prove a profitable recycling application.

Photo 27. This Roofing Shingle material was Hammermilled and Shaker separated into bituminum pieces and pea-gravel fines

Photo 28. Homogenized Shingle material extruding from the ATS Thermal Screw Press

COST ANALYSIS - RECYCLING OF SHINGLES

Table 17

DATA	Per hou	Per year	
Processing of raw material	3	7500	
Recovered material	80%	6000	
Operating hours		2500	
Number of Thermopresses		1	
Number of workers per shift	1	2500	
Cost of labor	$15	$37,500	
Consumption of power. KW	350	875000	
Cost of KW	$0.05	$39,375	
Cost of Thermopress			$410,000
Investment additional equipment (approximate)			$350,000
Interest rate			12%
Royalties payment per ton of raw material		Increase $0	$25
Depreciation period of investment(years)			3
Insurance (percentage on investment)			2%
Maintenance (percentage on investment)			4%
Tipping and hauling fee	$37		
Value of recoverd product	$180		

FIXED COST	PER YEAR	Per Ton
Capital cost on investment	$316,425	$42
Insurance	$15,200	$2
Maintenance	$30,400	$4
TOTAL FIXED COST	$362,025	$48
OPERATING COST		
Labor	$37,500	$5
Energy	$39,375	$5
Royalties	$187,500	$25
TOTAL VARIABLE COST	$264,375	$35
TOTAL COSTS	$626,400	$84
PER TON OF RECOVERED MATERIAL		$104
SAVING		
Tipping and hauling fee	$277,500	$37
Value of product	$1,080,000	180
TOTAL SAVING	$1,357,500	$217
PROFIT	$731,100	$181
PER TON OF RECOVERED MATERIAL		$122

APPENDIX 1 WASTE ANALYSES

DATE	November 15 1
HRI PROJECT	002-96M
HRI SERIES NO.	40578-A
DATE RECD.	10/31/88
CUST P.O.#	

Biomass Energy Investment
Mr. H. Adam Bosschieter
17604 East Kings Canyon - #36
Sanger California 93657

REPORT OF ANALYSIS

SAMPLE NO. 40578-1
SAMPLE IDENTIFICATION: Wood Chips

Moisture,% (As Received Basis)	11.56
Ash,% (As Received Basis)	2.32
Calorific Value,BTU/LB (Dry Basis)	8521
Ash,% (Dry Basis)	2.62

By:

Coal Laboratory Supervisor

DATE December 17, 1987
HRI PROJECT 002-50-C
HRI SERIES NO. 37530
DATE RECD. 12/11/87
CUST P.O.#

Mr. H. Adam Bosschieter
c/o Maple Lift Company
421a Bowes Road
Concord, Ontario L4K 1J5
CANADA

REPORT OF ANALYSIS

SAMPLE NO. 37530-1
SAMPLE IDENTIFICATION: Paper Waste

AS RECEIVED	
Moisture, %	9.07
Ash, %	9.15
BTU/LB	7103
DRY	
Ash, %	10.06
BTU/LB	7811
Air Dry Loss	7.25

By:
Coal Laboratory Manager

*Correction to report dated December 17, 1987.

DATE March 22 1988
HRI PROJECT 002-041
HRI SERIES NO. 38301
DATE RECD 3/15/88
CUST P.O.#

REPORT OF ANALYSIS
PREPARED FOR:

AREA:

Maple Lift
Mr. H. Adam Bosschieter
421 Bowers Road
Concord Ontario L4K 1J5

COAL ANALYSIS REPORT

HOLE#

REPORTING BASIS >	AS RECEIVED				DRY				AIR DRY LOSS %
INTERVAL	MOIST. %	ASH %	BTU/LB	SULFUR %	ASH %	BTU/LB	SULFUR %	MMF BTU/LB	
Comp. Bark Logs	9.63	7.43	7194		8.22	7961		8737	

DATE March 22 1988
HRI PROJECT 002-041
HRI SERIES NO. 38301
DATE RECD. 3/15/88
CUST P.O.#

Maple Lift
Mr. H. Adam Bosschieter
421A Bowers Road
Concord Ontario L4K 1J5

REPORT OF ANALYSIS

SAMPLE NUMBER	SAMPLE IDENTIFICATION	Bulk Density
38301-1	Comp. Bark Logs	1.19

FAX 477-2910 TWR
ATT ASHOK COLAN
FROM. LORNE WARNER

CONFIDENTIAL LAB REPORT

To: Andy Lodge	TESTED AT: IKO Research Centre REPORT NO: IR-013-89 DATE : 9-25-89 MADE AT : TWR

AMPLE DESCRIPTION:
1 log of recycled, extruded, asphalt Roofing - 3" x 10" approx.

UBMITTED BY: Lorne Warner	OBTAINED FROM: TWR ?
EQUESTED TEST: Analysis for granule sizing.	REASON FOR REQUEST: Check for reduction in granule sizing.

OMPLAINT REF. NO: N/A	DATE SAMPLES REC'D: 04-89	SAMPLE NO.: 89-025

ISPOSITION OF SAMPLES:
Extracted granules retained, remainder of original sample retained.

Comments:

A random sample was extracted in a thimble and the extracted solid was ashed at 500°C for 2 hours to remove the organic felt. The ashed material was sieved through 14 and 35 mesh screens to separate the granules.

The percent distribution of the granules on the 14 and 35 mesh screens was 14% and 86% respectively. Normally the distribution is 40% and 50% (more coarse granules).

One interpretation of the results is that granule size reduction was acheived in the trial. (40% on 14 mesh reduced to only 14% of the granule mass). However, it should be pointed out that;

a) Although a reasonable size sample was extracted. there was only 5.1 g of granules in total. This may not be a large enough sample to give a true granule size analysis.
b) A separate screening on the +14 mesh fraction showed there were some +10 mesh granules.

The fact that there were still some +10 mesh size granules leads the writer to question if size reduction actually occurred. If these granules made it through uncrushed, why would others be crushed? If the machine clearance was greater than the width of a 10 mesh granule, it seems unlikely that two granules could be perfectly positioned to crush each other. They would more likely release the potential crushing energy by moving "sideways" in the slurry.

Also, even if some of the 10 mesh did crush, they only account for about 5% of the original sizing. Most of the size reduction would have to occur in the smaller 14 mesh.

Signed: Lodge

APPENDIX 2 AGRICULTURE CANADA MEMORANDUM

RETYPED FOR EASY READING

Agriculture
Canada

Food Production and
Inspection Branch

March 14, 1989

MEMORANDUM TO: Dr. N.G. Willis
Director General
Health of Animal Directorate

Dr. G. Dittberner
A/Director General
Veterinary and Agricultural Inspection Directorate

SUBJECT: Approval of Process being Developed by Econoler Inc., for the Thermal Treatment of International Garbage

At Lester B. Pearson International Airport (LBPIA), Econoler Inc. has been developing a process for the thermal treatment of international waste so that the treated garbage may be disposed of in an approved sanitary landfill site in compliance with Section 47 of the Animal Disease and Protection Regulations (ADP Regs.). The process was assessed by Drs. A. Stewart and G. Mraz of the Ontario Region, VID, and Dr. B. Jamieson of the Animal Health Division. It was determined that the equipment does heat the garbage to a temperature in the garbage for 30 minutes, thereby meeting the heat treatment requirements of Subsection 47. (3) (b) of the ADP Regs. A more detailed description of the function and assessment of the equipment may be found in the attached statement of evaluation of the process.

It must be noted that approval of the heat treatment process by Agriculture Canada relates Specifically to its effectiveness in the thermal treatment of waste and does not reflect on the suitability of a single compactor unit plus sterilizer to treat large volumes of garbage or the mechanical soundness of the equipment.

It is further noted that, upon the acceptance of the equipment by the Airlines, inspection will be on an ad hoc basis prior to the development of the standards for inspection, which will have been completed no later than May 31, 1989.

It is therefore recommended that the thermopress/sterilizer apparatus developed by Econoler Inc. be approved for the heat treatment of international waste subject to the following conditions, having net the requirements of Section 47 of the Animal Disease and Protection Regulations.

1. The five (5) thermocouples which measures the internal temperature of the equipment at various stages in the process shall be recalibrated to verify their accuracy in the presence of an Agriculture Canada officer who shall then seal the compartment containing the adjustment of each thermocouple. The applied seals shall remain in lace during the operation of the equipment, being removed only by an Agriculture Canada officer.

2. The control for adjusting the speed of the conveyor system in the sterilizer unit shall be set at a reading of 83 units and modified in a manner that it may be either (i) rendered non adjustable or (ii) sealed at that setting, with any such seal being removed only by an Agriculture Canada officer.

3. Concerning the recording of temperatures achieved in the heat treatment process, the hard copy printout of the temperatures reached at each of the five sensor locations must accurately reflect the temperature at the specific time of a specified day, temperatures shall be recorded for all hours of operation, the on-duty supervisor of operations shall sign and manually record the date and time of signing on the hard copy record for each day's operation thereby certifying its accuracy, and such records shall be retained to be made available to departmental inspectors at all times. Additionally, although not essential, it is desirable to have the current format of the graph-type printout modified so that the only remaining horizontal line for each thermocouple record represents 100 C and all entries indicate a temperature above or below that reading.

...3/

Your acceptance of this process will provide the Airlines with an alternate means of disposing of international waste at LBPIA and possibly other sites in the future.

W.S. Bulmer
Director
Animal Health Division

Enclosure

I accept

Dr. N. G. Willis

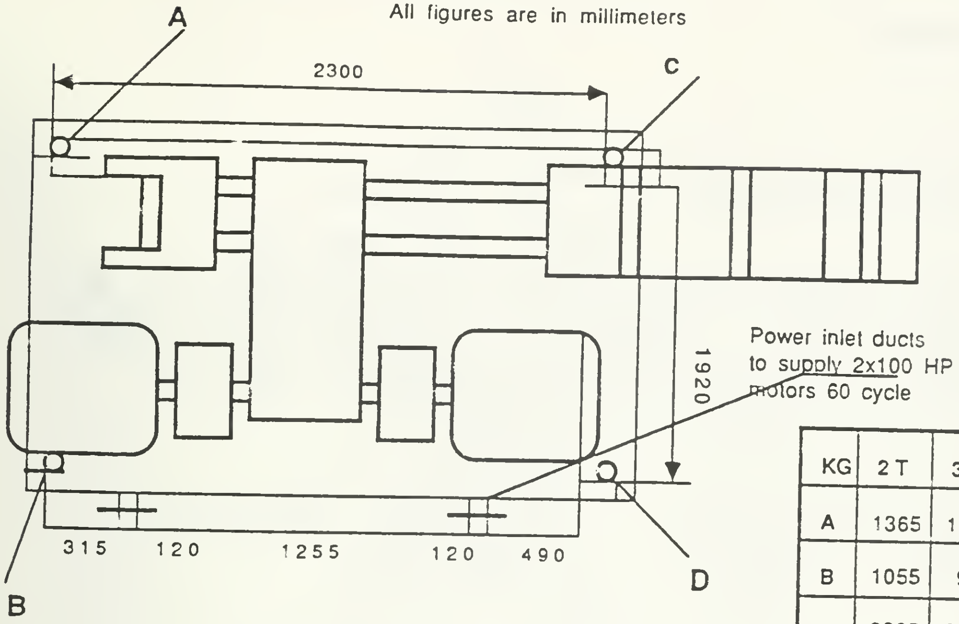
I accept

Dr. G. Dittberner

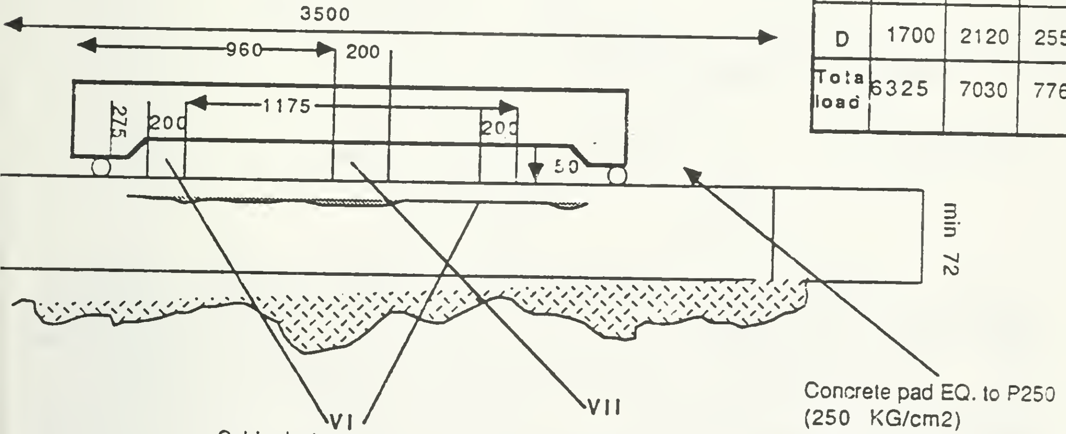
APPENDIX 3 ATS-TSP COMPONENTS & FOUNDATION PLAN

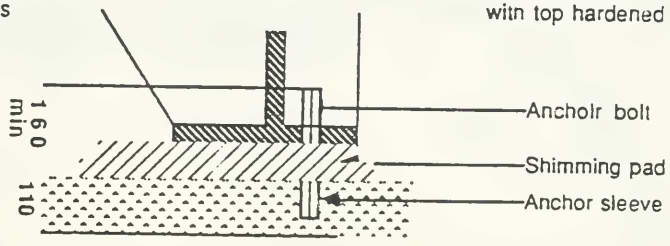
FOUNDATION PLAN FOR THE ATS PRESS

All figures are in millimeters



KG	2 T	3 T	4 T
A	1365	1215	1070
B	1055	940	825
C	2205	2755	3315
D	1700	2120	2555
Total load	6325	7030	7765

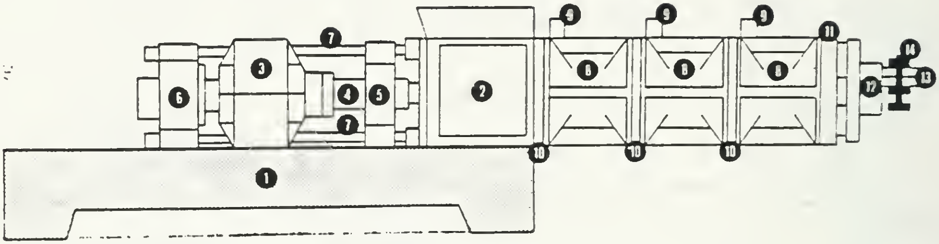




Foundation plan

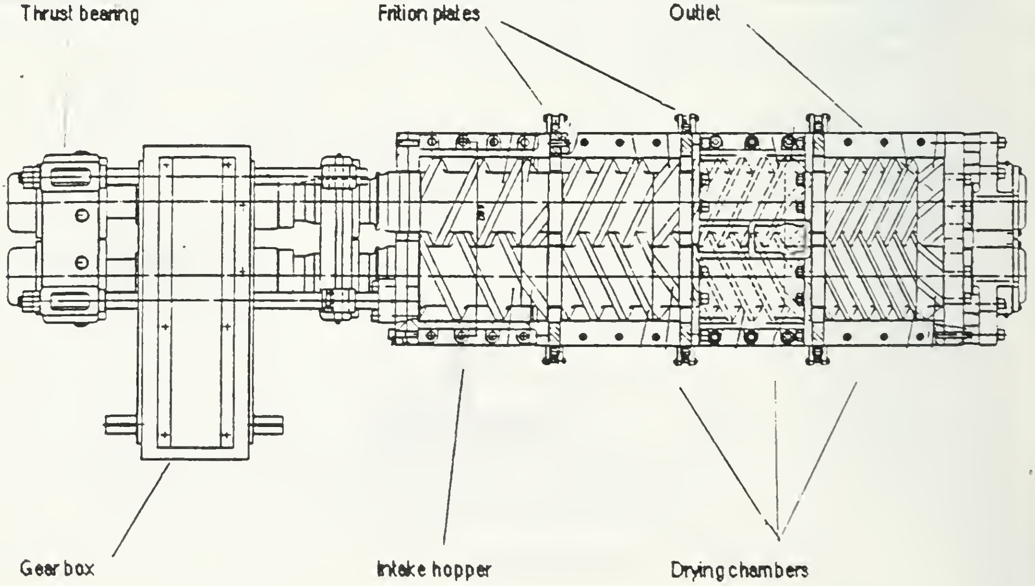
3.4 Components

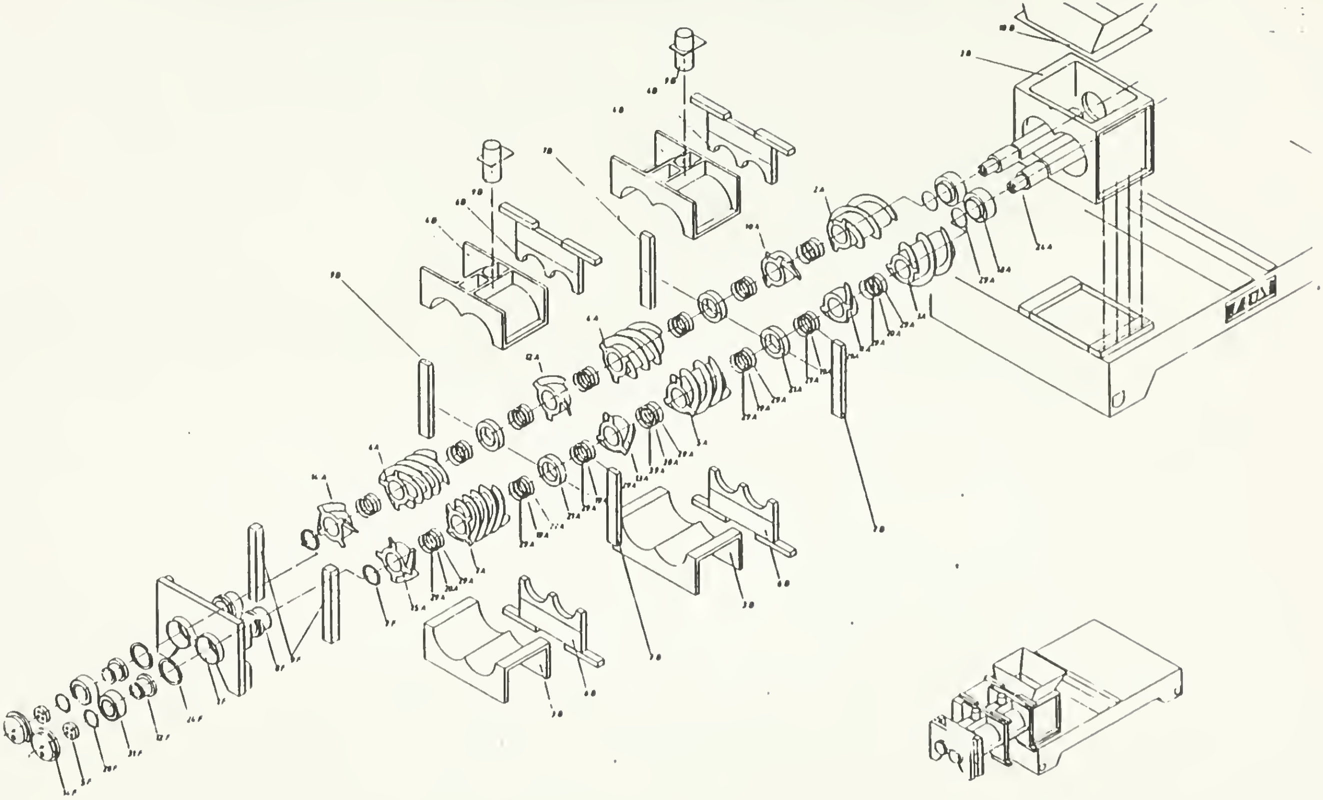
Component parts of the Thermo Screw Press
illustrated by a 4-part ATS-TSP



1 Machine base
2 Charging device
3 Gear
4 Driving shaft
5 Expanding thrust bearing
6 Thrust bearing
7 Tie rods
8 Thermal stages
9 Steam exhausts
10 Sliding plates
11 Delivery plate
12 Delivery bearing
13 Die
14 Tension device

3.5 Internal design of the press. [Figure 2]





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